SCIENCE

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MSS. intended for publication and books, etc., intended for review should be sent to the responsible editor, Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

THE ADMINISTRATION OF GOVERNMENT SCIENTIFIC WORK.

A CORRESPONDENT, whose letter is printed in another column, calls attention to the oft-recurring questions of the superintendency and organization of the U. S. Coast and Geodetic Survey. Whatever may be the merits or demerits of the considerations adduced by this correspondent with reference to matters of detail, it is evident that the essentials of these questions are quite as important now as they have been at any time during the past half-century. These essentials are, in fact, not limited in their application to any one scientific bureau of the government, but are of equal importance to all of them. The question of reorganization of the Naval Observatory is now pending, after a long and painstaking investigation by a committee specially delegated to consider the matter; and the question of the establishment of a new bureau which may take charge of the indispensable business of national standards is likely to come up in the near future. The mode of selection of a head, or director, of any one of these scientific bureaus is, then, or at least ought to be, a matter of concern to all men of science; for whatever mode is

applied in any case is likely to serve as a precedent for the next.

It goes without saying that the method of selection of such heads is, in our country, an unsatisfatcory one. Not that this method always secures incompetent appointees; many eminent men have come thus into the government service in spite of the method; but it presents an open door to the formidable class of opportunists whose claims to high office are not based on professional qualifications. Thus, not infrequently, notoriously unfit men are placed temporarily in charge of the highest grades of scientific work. Their ridiculous careers in such rôles are generally short, but yet long enough to establish precedents which place-hunters of all sorts are not slow to utilize. Hence it follows that the tenure of office of the heads of our scientific bureaus is short; that the conduct of bureau work is usually less effective than it ought to be; and that the employees in such bureaus are periodically distracted with the fear that at the next turn of the kaleidoscope they may find themselves officially decapitated. It is a fact, we believe, that the superintendents of the Coast and Geodetic Survey have succeeded one another during several decades with a rapidity only surpassed by that of recent political events in China. One may well marvel how, under such adverse conditions, it has been possible for this bureau to accomplish so much first-class scientific work as is actually recorded in its bulky annual reports.

But the practical enquiry in this connection is, 'what are we going to do about it?' How long is it going to be possible, for example, for mere 'influence,' often prepared in the most shameless manner, to stampede the President of the United States into appointing to professorships of mathematics in the navy men who know nothing of that science, or into appointing to the superintendency of the Coast and Geodetic Survey men who may convert that bureau into a manufactory of ten-place logarithms?

Our correspondent suggests, we think, a practicable way out of the difficulty. It does seem proper, as he urges, that the scientific organizations of our country should interest themselves in matters which, according as they are well or ill administered, must reflect credit or discredit on American science. Why may not the National Academy of Sciences become in fact, as it is by law entitled to be, the adviser of the government in matters scientific? Or, if it is for any reason impracticable for this Academy to fulfill its natural functions, why may we not have a board of regents, similar to that of the Smithsonian Institution, whose duty it shall be to give the government advice concerning the direction of national scientific work? There is no reason, apaarently, why we may not have such an advisory body unless it be the inadequate reason of 'general apathy.' Our government could, if it would, and our scientific organizations can, if they are willing to make the effort, secure just such expert advice as is needed free of cost. We venture to assert, for example, that if either the National Academy of Sciences or the American Society of Civil Engineers were asked to do so it would speedily suggest two or three eminently worthy candidates for the

position of superintendent of the Coast and Geodetic Survey or for the directorship of the proposed bureau of standards. Moreover, it is believed that either of these societies would be willing to cite in the public prints reasons for the fitness of such candidates based on lists of their published works and on histories of their professional careers. It is doubtful, of course, whether an eminently fit person would, under existing circumstances, accept such a position; but the establishment of a high standard of appointment would help more than any thing else to make the position worthy of an able man and to make his tenure of office reasonably secure.

Has not the time arrived when the scientific societies of the country should unite in an effort to raise the standard of qualifications for a directorship of government scientific work? We believe the time has come; and we believe also that Congress would welcome the advice of a representative committee of scientific men of the country on all questions relating to the work and administration of our scientific bureaus.

It may be said, however, that experience has revealed well-nigh insuperable difficulties in the way of the needed changes. One must confess, in fact, that the reforms of the democratic and republican administrations of the Coast and Geodetic Survey during the past twenty years have corrected only minor evils; and that the efforts of the past thirty years to get the Naval Observatory on an astronomical rather than on a naval footing have proved almost fruitless. But depressing as this experience is, it ought not to suppress the optimism of patriotic men of science. It ought rather to lead them to renewed studies of these perennial questions, especially since the prosecution of scientific work is apparently coming to be more and more a part of the business of civilized nations the world over. Possibly the reformers have failed hitherto because they have sought to accomplish too much, or because they have sought to accomplish the wrong things. The problems presented are evidently very complex, and their solution may be unattainable except by the method of successive approximation. Perhaps we should be content as a first step to secure the necessary legislation for the creation of a board of advisers with reference to appointments to prominent positions in the scientific bureaus. It is hardly conceivable that such a board would, if composed of well-known men, ever propose any one conspicuously unfit for official position. Once establish the custom of choosing only men of good scientific repute to direct scientific work, and there would be little danger of relapse to the present haphazard system. In short, the plane of reference for appointments to national posts of honor and trust in science needs to be raised at least to the level of that which is applied in the case of appointments to justiceships in the Supreme Court. When the office seeks the man, and when the office is worthy of the untiring devotion essential to eminence in science, our government will secure officers of whom we need not feel ashamed, and the petty annoyances of which our correspondent complains, in a measure justly, no doubt, will disappear without special attention.

*A DETERMINATION OF THE NATURE AND VELOCITY OF GRAVITATION.**

The present note is to be taken as a supplement to my previous paper on 'The Nature of the Electric and Magnetic Quantities.'† A fuller development of the theory of gravitation advanced by the writer is in course of preparation. This will, however, be delayed for some time, possibly for several years, as it is desired to investigate certain phenomena rather more accurately than has hitherto been done, and at present the writer is occupied with pressing work in another line.

It has seemed advisable, however, to publish this determination of the velocity of gravitation at the present time, and without waiting to complete the fuller treatment, for the reason that, as will be seen later, the value obtained clears up a number of perplexing optical problems, and removes a number of obstacles which have hitherto stood in the way of the development of that branch of physics.

On account of the fact that the writer's papers on these subjects have unavoidably been published in somewhat scattered form, it is considered best to give a brief résumé of the work which forms the basis of the method by which this velocity is deduced.

In 1893 the writer perceived that Fourier's 'Dimensions' could be developed into a very powerful agent of research, and one which should bear a relation to the usual methods similar to that which Qualitative chemistry bears to Quantitative. It was for this reason that the name 'Qualitative Mathematics' was given to this new branch.

As its name signifies, it is used, not for the exact determination of numerical quantities, but for the prediction and classification of phenomena.*

It was first shown† that the nature of electricity and magnetism was, at that time, indeterminate, as all the electric and magnetic phenomena which we were able to completely express dynamically could be comprised in three qualitative equations, whilst we had four unknown quantities.

Then, by several methods, Williams's result, that either specific inductive capacity, (k), or permeability (μ), must be a density, the other term being a compliancy, was confirmed.

It was then further deduced that the one which is a compliancy must decrease with the first power, whilst the one which is a density must decrease with the second power, of the corresponding intensities, *i. e.*, if F be the electric potential difference per unit length, and H be the magnetic potential difference per unit length, then if μ be

* Being a supplement to 'A Determination of the Nature of the Electric and Magnetic Quantities and of the Density and Elasticity of the Ether.'

† *Phys. Rev.*, January, 1900; and also of the earlier papers: 1891–2, on 'The Laws and Nature of Cohesion.'

* Such a branch of mathematics is absolutely necessary to supplement the work done by the other methods. For the latter can tell us nothing of the *nature* of the quantity involved. Their very greatest strength is their greatest weakness. The fact that a certain function, which gives us the state of things at the end of an organ pipe, also gives us the way a current of electricity distributes itself near the end of a wire dipping in a mercury cup is gratifying in its compre hensiveness, but disappointing in that when we meet that function, we do not know which of the many possible phenomena it represents. Take, for instance, our equations for light. They fit in with a simple elastic-solid wave, and we have fallen into the habit of speaking of light as really being such a wave, and some eminent physicists, even, as I have pointed out elsewhere, have fallen into the mistake of supposing that the magnetic rotation of light necessarily implies a rotation of the medium in a magnetic field, overlooking the fact that the whole proof is based on this unfounded, and, as we now know, certainly incorrect, supposition. All that the equations really mean is that light is some kind of periodic motion, but, if I remember rightly (as it was some years ago that I investigated the matter), there are eight kinds of periodic motion which can be equally well represented by the light equations.

† *Ibid.*, also *Elect. World*, May 18, 1895.

a compliancy, on increasing H, μ will decrease by an amount depending upon the first power of H, and on increasing F, k will decrease by an amount depending upon the second power of F. Also, in this latter case, the diminution of k must depend inversely upon the coefficient of volume elasticity.

On the other hand, if it is k which is the compliancy, these relations will be interchanged.

It was at once noticed that several of the empirical formulæ expressing the relation between H and μ gave a diminution depending upon the first power of H. A somewhat elaborate investigation was then undertaken, extending over the greater part of a year, and the fact was definitely established that the diminution did depend upon the first power of H accurately, the maximum amount of deviation from that called for being less than one-fourth of one per cent., which was about the limit of experimental accuracy.

This, of itself, would have sufficed to have settled the point, but in addition the other relation, which should exist if the theory were correct, *i. e.*, that the specific inductive capacity, k, should vary with the inverse second power of the slope of electric potential, and as the coefficient of volume elasticity, was also discovered. This was found to be the complete expression of Kerr's electrostatic phenomenon.

A prism of glass, one cm. thick and one cm. wide, stretched with a force of 30.10^6 dynes gave a change of density of nearly 3.10^{-5}. The change in the thickness of the glass was approximately $1.5.10^{-5}$. The change in velocity of the light which passed transversely through the glass, was approximately $.7 \times 10^{-5}$.

It was thus found that the actual mechanically produced change in density of the glass was sufficient to account for the observed change of velocity, though the agreement was not so close as it might have been, possibly owing to experimental difficulties.

From the observed change in velocity when placed in a strong electrostatic field, whose value was approximately determined by its sparkling distance, it was calculated that the value of the $F^2/8\pi k$ stress required to produce the same change of velocity as had been produced mechanically was nearly 25.10^6 dynes. The value of the purely mechanically applied stress, as given above, was 30.10^6. The close agreement is probably accidental, as the experimental error was considerably greater than the small difference observed. It is intended to repeat these experiments under conditions permitting of a much higher degree of accuracy.

The results obtained are however sufficient to show that Kerr's effect can be accounted for by purely mechanical stresses, electrically produced and resulting in a change of density.

Now it was pointed out above, that whichever of the medium coefficients, k or μ, varies as the square of the corresponding intensity, that one must be a density. Since, therefore, it has already been shown by Kerr that the change in velocity, and hence, as my experiments prove, the change in density,* is proportional to the square of the electric intensity, it follows that k is a density.

It still remained to be shown that Kerr's effect depended upon the volume elasticity. This was done by testing different glasses and noting that, the compensating pieces being made from the glass under test, the same force was always required to compensate, independent of the material tested.

We see, therefore, that the results deduced from the experiments on the relation between H and μ are completely confirmed

* Velocity is proportional to square root of density, but change of velocity is proportional to change in density, both being small.

by the results obtained on investigating the relations between F and k.

A number of additional pieces of corroborative evidence were also given, *i. e.*:

3. The relation between the magnetic constant a and the elasticity.

4. The relation between this constant and elastic strain.

5. The relation between this constant and permanent strain.

6. The relation between this constant and hysteresis.

7. The relation between k and the density of substances.

Several phenomena were also predicted, *i. e.*:

A. A change in the velocity of light, along a slope of electric potential.

B. A relation between refractive index and piezo-electric effect in doubly refracting substances.

These have not yet been confirmed, but arrangements are being made to investigate the former.

This same result, originally obtained by qualitative mathematics, can also be obtained by Lagrangian methods. By considering the way in which permeability and specific inductive capacity are affected in the case of stressed iron, and in the case of Kerr's phenomenon, as influenced by the elasticity of the material, it can be shown that a change in μ involves the first power of the magnetic intensity and that a change of k involves the second power of the electric intensity. This proof will be given later. It, however, in reality, adds nothing to the proof already given, which in the opinion of the writer is of such a character that we may say that the nature of electricity and magnetism is now definitely and finally determined, though no doubt it may be years before the absolutely decisive nature of the proof is generally appreciated.

Next, it follows from the writer's experiments on the relation between H and μ that the presence of matter does not alter the elasticity of the ether by as much as one-fourth of one per cent. Also, knowing now that k is a density, we are enabled to say that aberrational and other optical phenomena show that the density of the ether is not appreciably altered by the presence of matter, otherwise the $(n^2 - 1)$ and similar formulæ would not hold. From these facts we see that the actual volume of the atom, compared with the space occupied by it, must be quite small.

The diameter of the mercury atom I have shown to be $2.75\ (\pm 0.2) \times 10^{-8}$, and in 1899 I showed that the actual cross section of the space actually occupied by the atom must be less than one four-hundredth of the space occupied by the atom to the exclusion of other atoms, and that the atoms 'must have a configuration analogous, in its effects, to that of structures of thin platinum wire, suspended in oil.'

Later, J. J. Thomson, from his beautiful and wonderfully ingenious work on electric discharges in gases, was able to show that the atom is made up of a number of smaller bodies, which he calls corpuscles.

On comparing the results of Thomson, Ewers, Kaufmann, Lenard, Lorenz, Wiechert and Simon, we arrive at the conclusion that there are about 1,000 corpuscles in a hydrogen atom, and that the weight of a corpuscle is therefore about 1.5×10^{-27} gm.

Since, then, there are about 200,000 corpuscles in a mercury atom, and their cross section is less than one four-hundredth part of the cross section of the mercury atom, we find that the diameter of the corpuscle is certainly less than 2.10^{-11} cm.

From J. J. Thomson's formula for the electrically produced inertia of a charged sphere, we find, as was shown by Thomson (and independently by the writer), that if the diameter of the corpuscle is approximately 10^{-13} cms., the ionic charge which

it carries will account for its full quantity of inertia.

So long as we knew nothing of the size of the corpuscle, and since there might be a thousand corpuscles in a hydrogen atom, and yet each corpuscle be about 3.10^{-9} cms. in diameter, we were hardly justified in holding that inertia is an electric phenomenon. But when we take into consideration, in addition, the writer's proof that the diameter of the corpuscle must be less than $\frac{1}{1000}$ the diameter of the atom, and that this is the *superior* limit in size, we have a reasonable basis for holding, as the writer has done,* that the corpuscular charges are the cause of the inertia of matter.

Assuming this, we arrive at the result that the corpuscle is about $\frac{3}{4} \times 10^{-15}$ cms. in diameter. The ionic equivalent being about $4\ (\pm 1) \times 10^{-10}$ e. s. units, we find for the electrostatic tension and pressure at the surface of the corpuscle, about 2.10^{33} dynes.

One of the theorems immediately deducible by Qualitative Mathematics is that, "Whenever the electric or magnetic forces act in the presence of matter, the resultant effect is made up of two terms, one expressing the result of the action on the matter, the other that of the action on the ether."

We have seen that the electric stresses produce a change of volume in matter, and hence we must have also an effect of the same quality in the ether. Such a change of density in the ether would produce a gravitational attraction, and we may now calculate what value the ether constants must have in order to produce the observed amount of gravity which is associated with the corpuscle.

Taking Boys's value for the gravitational attraction of two masses, each of one gramme, and one cm. apart, *i. e.*, 6.65×10^{-8}, we get for the gravitational energy of the corpuscle about 10^{-48} ergs.

* *Elect. World*, May, 1900.

From this and the electrostatic stress we can calculate the volume elasticity, and we find it to be about 10^{73}.

But I have previously shown that the density of the ether is about 0.66 and its rigidity about 6.10^{20}.

Hence we can calculate the value of the compressional or gravitational wave, and find it to be approximately 5.10^{36} cms. per second.

It will be at once seen that this value agrees with our astronomical facts, and that it does away with a great many optical difficulties. For in the first place it makes the compressional wave vanish, and in addition, which is of the greatest importance, it makes the amount of energy in the compressional wave infinitesimally small.*

We may summarize our conclusions as follows:

The ether itself is a composite body, having a structure whose elastic properties are analogous to rubber. This is shown by the low value of the rigidity as compared with the compressibility, and by the form of the equation expressing the relation between H and μ.

This would immediately suggest a vortex theory, even if the quality of the ionic charge, *i. e.*, M/T, were not called to the attention. If we take Fitzgerald's vortex theory, and develop it along the lines indicated by my theory we have the vortices analogous to what, in the case of india rubber, I have called the 'skein material,' and the fluid in which the vortices form, which,

* In a paper on Comet's Tails, *Astrophysical Review*, January, 1897, the writer showed that all the phenomena so far noted in this connection, including the bridge of Biela's comet, the apparent retardation, the shape, etc., could be accounted for by supposing that the ultra-violet light of the sun acted on the surface of the nucleus of the comet to throw off negatively charged particles. It is possible that this compressive wave may be a factor in this discharge, though on the other hand it is possible that the light itself may be sufficiently effective.

until some one suggests a better name, we will call ethēron, taking the place of the 'filling-in material.'* The compressibility of the ethēron is very high, as we have seen, it being the thing which determines the velocity of the compressive wave. The vortex structure is what is concerned in transmitting the light waves and its modulus; the rigidity modulus is much smaller and of a different order, just as in the case of india rubber.

We do not need more than one vortex, 'the umbilical cord of the universe,' as one aspect of it suggested itself, stretching with its ends fixed on some free surface of the ethēron and itself forming one inextricable tangle. The circulation being the same everywhere simplifies matters. The parting of the vortex anywhere means the destruction of all matter.

Such a medium, as Fitzgerald has shown, gives an ether which can transmit light. Following up this theory, we conclude that corpuscles are vortex singularities, and that it is the hydrodynamic head of their flow which gives the ethēron density-variation round them. This change in density varies as the fourth power of the distance from the corpuscle. All the gravitational energy tends to that of compression, and if two corpuscles come together, their gravitational energy goes to increasing the compression energy of the ether. They do not come together because their approach brings into play forces which depend upon the energy of the vortices themselves. The fact that there is but one vortex, and consequently the circulation is the same everywhere, gives the atoms definite sizes and the corpuscles the same quantity of electricity, *i. e.*, the ionic charge.

A group of so many thousands of these corpuscles makes up the atom. The inertia of the atom is due to the electromagnetic inductance of the corpuscular charge, and gravity is due to the change of density of the ether surrounding the corpuscles, produced by the electrostatic stress of the corpuscular charge. Mass and gravity thus bear a constant ratio.

The cohesive force of the atoms, as I have shown elsewhere,* is due to the electrostatic attraction of the atoms for one another. Chemical force, as has been shown by Davy, Berzelius, Helmholtz, Ostwald and other workers, is due to the same cause.

It may here be noted that the idea of the ionic charge as an ever-present element of the atom is an interesting example of a theory, negatived absolutely, apparently, by fundamental principles, and yet developing in spite of its apparent incompatibility with facts in many other directions, with such success as to finally obtain a firm footing, although the arguments against it have never been answered.

The fact that the ionic charge is the agent in chemical action had been shown by the physicists just mentioned above. The presence of charged ions in electrolytes had also been firmly established, and J. J. Thomson had suggested that conduction in metals also took place through a breaking up of molecular groups, as in the case of electrolytes. But when in 1890 and 1891† I introduced the theory that the ionic charge is attached to the atom, *not only when it is concerned in chemical actions or formed part of a molecule, but in every case and always*, and is the cause of a number of physical phenomena, such as cohesion, rigidity, etc., a number of objections were made; that charges could not exist in the interior of a conductor; that the atoms of metals must be conducting, and so could not have equal charges of electricity; and others, as for example, the well founded

* Ether is the structure formed by the fluid and the vortices, ethēron the fluid alone.

**Elect. Soc.*, Newark, 1890; *Elect. World*, Aug. 8–22, 1891.

† *Ibid.*

criticism of Ostwald (under date Sept. 16, 1891): "The electrostatic theory of cohesion is new to me, * * * but for electrolytes there is the question to be answered, why stuffs like alcohol, etc., do not conduct? whilst according to *your* theory, *all* elements have electric charges."

These objections could not be met then, and have not been met up to the present time, in spite of the fact that this new concept (of the ionic charge being a fundamental part of the atom, apart from its chemical functions) has proved a most fertile one, and has been considerably developed by the orignator and by later workers, Richartz, Chattock, Lorentz, Larmor and others. Nor will these objections ever be met until we know the nature of metallic conduction.

This is one of the great outstanding problems. It has long been known that there is a relation between electric and heat conductivity. The writer has shown that there is a connection between the velocity of sound (and hence the elasticity and density) and the electric conductivity of wires. J. J. Thomson, as mentioned above, suggested that the current was carried by the electrolysis of molecular groupings, and his later work renders it probable that it is by means of the corpuscles. It is possible that the atoms of a metal are really dissociated and the negatively charged corpuscles are in a state similar to that of the ions of a solution, *i. e.*, the metallic atom is not a fixed combination of certain corpuscles, but is constantly changing in composition, the negative corpuscles being, as it were, in solution in the metal, and changing about freely.

Such an hypothesis would account for the relation between the velocity of sound and the electric conductivity. For the cohesion of the atoms would be due to these negative corpuscles acting, as the mortar between bricks, to bind together the positive groupings, and hence the greater the number of free corpuscles the greater the elasticity and the greater the conductivity, the conductivity being simply the number of free corpuscles per cubic centimeter. The greater the number of corpuscles in the positive groupings, *i. e.*, the greater the molecular mass, the less the conductivity.

In presenting this summary I am aware, of course, that much of it is in need of further experimental evidence, and I hope, in time, to supply at least a part of this. It is considered, however, that the scheme here presented has a weight apart from its experimental foundation, in that it is a whole and consistent theory by which for the first time all physical phenomena are reduced to the simplest possible elements.

REGINALD A. FESSENDEN.

ADDRESS OF THE PRESIDENT OF THE SECTION OF GEOLOGY OF THE BRITISH ASSOCIATION.

I.

EVOLUTIONAL GEOLOGY.

THE close of one century, the dawn of another, may naturally suggest some brief retrospective glance over the path along which our science has advanced, and some general survey of its present position from which we may gather hope of its future progress; but other connection with geology the beginnings and endings of centuries have none. The great periods of movement have hitherto begun, as it were, in the early twilight hours, long before the dawn. Thus the first step forward, since which there has been no retreat, was taken by Steno in the year 1669; more than a century elapsed before James Hutton (1785) gave fresh energy and better direction to the faltering steps of the young science; while it was less than a century later (1863) when Lord Kelvin brought to its aid the powers of the higher mathematics and instructed it in the teachings of mod-

ern physics. From Steno onward the spirit of geology was catastrophic; from Hutton onward it grew increasingly uniformitarian; from the time of Darwin and Kelvin it has become evolutional. The ambiguity of the word 'uniformitarian' has led to a good deal of fruitless logomachy, against which it may be as well at once to guard by indicating the sense in which it is used here. In one way we are all uniformitarians, *i. e.*, we accept the doctrine of the 'uniform action of natural causes,' but, as applied to geology, uniformity means more than this. Defined in the briefest fashion it is the geology of Lyell. Hutton had given us a 'Theory of the Earth,' in its main outlines still faithful and true; and this Lyell spent his life in illustrating and advocating; but as so commonly happens the zeal of the disciple outran the wisdom of the master, and mere opinions were insisted on as necessary dogma. What did it matter if Hutton as a result of his inquiries into terrestrial history had declared that he found no vestige of a beginning, no prospect of an end? It would have been marvellous if he had! Consider that when Hutton's 'Theory' was published William Smith's famous discovery had not been made, and that nothing was then known of the orderly succession of forms of life, which it is one of the triumphs of geology to have revealed; consider, too, the existing state of physics at the time, and that the modern theories of energy had still to be formulated; consider also that spectroscopy had not yet lent its aid to astronomy and the consequent ignorance of the nature of nebulæ; and then, if you will, cast a stone at Hutton. With Lyell, however, the case was different: in pressing his uniformitarian creed upon geology he omitted to take into account the great advances made by its sister sciences, although he had knowledge of them, and thus sinned against the light. In the last edition of the famous 'Principles' we read: "It is a favorite dogma of some physicists that not only the earth, but the sun itself, is continually losing a portion of its heat, and that as there is no known source by which it can be restored we can foresee the time when all life will cease to exist on this planet, and on the other hand we can look back to a period when the heat was so intense as to be incompatible with the existence of any organic beings such as are known to us in the living or fossil world. * * * A geologist in search of some renovating power by which the amount of heat may be made to continue unimpaired for millions of years, past and future, in the solid parts of the earth * * * has been compared by an eminent physicist to one who dreams he can discover a source of perpetual motion and invent a clock with a self-winding apparatus. *But why should we despair of detecting proofs of such generating and self-sustaining power in the works of a Divine Artificer?*" Here we catch the true spirit of uniformity; it admittedly regards the universe as a self-winding clock, and barely conceals a conviction that the clock was warranted to keep true Greenwich time. The law of the dissipation of energy is not a dogma, but a doctrine drawn from observation, while the uniformity of Lyell is in no sense an induction; it is a dogma in the narrowest sense of the word, unproved, incapable of proof, hence perhaps its power upon the human mind; hence also the transitoriness of that power. Again, it is only by restricting its inquiries to the stratified rocks of our planet that the dogma of uniformity can be maintained with any pretence of argument. Directly we begin to search the heavens the possibility, nay even the likelihood, of the nebular origin of our system, with all that it involves, is borne in upon us. Lyell therefore consistently refused to extend his gaze beyond the rocks beneath his feet, and was thus lead to do a serious injury to our

science; he severed it from cosmogony, for which he entertained and expressed the most profound contempt, and from the mutilation thus inflicted geology is only at length making a slow and painful recovery. Why do I dwell on these facts? To depreciate Lyell? By no means. No one is more conscious than I of the noble service which Lyell rendered to our cause; his reputation is of too robust a kind to suffer from my unskilful handling, and the fame of his solid contributions to science will endure long after these controversies are forgotten. The echoes of the combat are already dying away, and uniformitarians, in the sense already defined, are now no more; indeed, were I to attempt to exhibit any distinguished living geologist as a still surviving supporter of the narrow Lyellian creed, he would probably feel, if such a one there be, that I was unfairly singling him out for unmerited obloquy.

Our science has become evolutional, and in the transformation has grown more comprehensive; her petty parochial days are done, she is drawing her provinces closer around her, and is fusing them together into a united and single commonwealth—the science of the earth.

Not merely the earth's crust, but the whole of earth-knowledge is the subject of our research. To know all that can be known about our planet, this, and nothing less than this, is its aim and scope. From the morphological side geology inquires, not only into the existing form and structure of the earth, but also into the series of successive morphological states through which it has passed in a long and changeful development. Our science inquires also into the distribution of the earth in time and space; on the physiological side it studies the movements and activities of our planet; and not content with all this it extends its researches into etiology and endeavors to arrive at a science of causation. In these pursuits geology calls all the other sciences to her aid. In our commonwealth there are no outlanders; if an eminent physicist enter our territory we do not begin at once to prepare for war, because the very fact of his undertaking a geological inquiry of itself confers upon him all the duties and privileges of citizenship. A physicist studying geology is by definition a geologist. Our only regret is, not that physicists occasionally invade our borders, but that they do not visit us oftener and make closer acquaintance with us.

EARLY HISTORY OF THE EARTH: FIRST CRITICAL PERIOD.

If I am bold enough to assert that cosmogony is no longer alien to geology, I may proceed further, and taking advantage of my temerity pass on to speak of things once not permitted to us. I propose, therefore, to offer some short account of the early stages in the history of the earth. Into its nebular origin we need not inquire—that is a subject for astronomers. We are content to accept the infant earth from their hands as a molten globe ready made, its birth from a gaseous nebula duly certified. If we ask, as a matter of curiosity, what was the origin of the nebula, I fear even astronomers cannot tell us. There is an hypothesis which refers it to the clashing of meteorites, but in the form in which this is usually presented it does not help us much. Such meteorites as have been observed to penetrate our atmosphere and to fall on to the surface of the earth prove on examination to have had an eventful history of their own of which not the least important chapter was a passage through a molten state; they would thus appear to be the products rather than the progenitors of a nebula.

We commence our history, then, with a rapidly-rotating molten planet, not impossibly already solidified about the center and

surrounded by an atmosphere of great depth, the larger part of which was contributed by the water of our present oceans, then existing in a state of gas. This atmosphere, which exerted a pressure of something like 5,000 pounds to the square inch, must have played a very important part in the evolution of our planet. The molten exterior absorbed it to an extent which depended on the pressure, and which may some day be learnt from experiment. Under the influence of the rapid rotation of the earth the atmosphere would be much deeper in equatorial than polar regions, so that in the latter the loss of heat by radiation would be in excess. This might of itself lead to convectional currents in the molten ocean. The effect on the atmosphere is very difficult to trace, but it is obvious that if a high-pressure area originated over some cooler region of the ocean, the winds blowing out of it would drive before them the cooler superficial layers of molten material, and as these were replaced by hotter lava streaming from below, the tendency would be to convert the high into a low-pressure area, and to reverse the direction of the winds. Conversely under a low-pressure area the in-blowing winds would drive in the cooler superficial layers of molten matter that had been swept away from the anticyclones. If the difference in pressure under the cyclonic and anticyclonic areas were considerable, some of the gas absorbed under the anticyclones might escape beneath the cyclones, and in a later stage of cooling might give rise to vast floating islands of scoria. Such islands might be the first foreshadowings of the future continents. Whatever the ultimate effect of the reaction of the winds on the currents of the molten ocean, it is probable that some kind of circulation was set up in the latter. The universal molten ocean was by no means homogeneous: it was constantly undergoing changes in composition as it reacted chemically with the internal metallic nucleus; its currents would streak the different portions out in directions which in the northern hemisphere would run from northeast to southwest, and thus the differences which distinguish particular petrological regions of our planet may have commenced their existence at a very early stage. Is it possible that as our knowledge extends we shall be able by a study of the distribution of igneous rocks and minerals to draw some conclusions as to the direction of these hypothetical lava currents? Our planet was profoundly disturbed by tides, produced by the sun; for as yet there was no moon; and it has been suggested that one of its tidal waves rose to a height so great as to sever its connection with the earth and to fly off as the infant moon. This event may be regarded as making the first critical period, or catastrophe if we please, in the history of our planet. The career of our satellite, after its escape from the earth, is not known till it attained a distance of nine terrestrial radii; after this its progress can be clearly followed. At the eventful time of parturition the earth was rotating, with a period of from two to four hours, about an axis inclined at some 11° or 12° to the ecliptic. The time which has elapsed since the moon occupied a position nine terrestial radii distant from the earth is at least fifty-six to fifty-seven millions of years, but may have been much more. Professor Darwin's story of the moon is certainly one of the most beautiful contributions ever made by astronomy to geology, and we shall all concur with him when he says, "A theory reposing on *veræ causæ*, which brings into quantitative correlation the length of the present day and month, the obliquity of the ecliptic, and the inclination and eccentricity of the lunar orbit, must, I think, have strong claims to acceptance."

The majority of geologists have long

hankered after a metallic nucleus for the earth, composed chiefly, by analogy with meteories, of iron. Lord Kelvin has admitted the probable existence of some such nucleus, and lately Professor Wiechert has furnished us with arguments—'powerful' arguments Professor Darwin terms them—in support of its existence. The interior of the earth for four-fifths of the radius is composed, according to Professor Wiechert, chiefly of metallic iron, with a density of 8.2; the outer envelope, one-fifth of the radius, or about 400 miles in thickness, consists of silicates, such as we are familiar with in igneous rocks and meteorites, and possesses a density of 3.2. It was from this outer envelop when molten that the moon was trundled off, twenty-seven miles in depth going to its formation. The density of this material, as we have just seen, is supposed to be 3.2; the density of the moon is 3.39, a close approximation, such difference as exists being completely explicable by the comparatively low temperature of the moon.

The outer envelope of the earth which was drawn off to form the moon was, as we have seen, charged with steam and other gases under a pressure of 5,000 lb. to the square inch; but as the satellite wandered away from the parent planet this pressure continuously diminished. Under these circumstances the moon would become as explosive as a charged bomb, steam would burst forth from numberless volcanoes, and while the face of the moon might thus have acquired its existing features, the ejected material might possibly have been shot so far away from its origin as to have acquired an independent orbit. If so we may ask whether it may not be possible that the meteorites, which sometimes descend upon our planet, are but portions of its own envelope returning to it. The facts that the average specific gravity of those meteorites which have been seen to fall is not much above 3.2, and that they have passed through a stage of fusion, are consistent with this suggestion.

SECOND CRITICAL PERIOD. 'CONSISTENTIOR STATUS.'

The solidification of the earth probably became completed soon after the birth of the moon. The temperature of its surface at the time of consolidation was about 1,170° C., and it was therefore still surrounded by its primitive deep atmosphere of steam and other gases. This was the second critical period in the history of the earth, the stage of the 'consistentior status,' the date of which Lord Kelvin would rather know than that of the Norman Conquest, though he thinks it lies between twenty and forty millions of years ago, probably nearer twenty than forty.

Now that the crust was solid there was less reason why movements of the atmosphere should be unsteady, and definite regions of high and low pressure might have been established. Under the high-pressure areas the surface of the crust would be depressed; correspondingly under the low-pressure areas it would be raised; and thus from the first the surface of the solid earth might be dimpled and embossed.*

THIRD CRITICAL PERIOD. ORIGIN OF THE OCEANS.

The cooling of the earth would continuously progress, till the temperature of the surface fell to 370° C., when that part of the atmosphere which consisted of steam would begin to liquefy; then the dimples on the surface would soon become filled with superheated water, and the pools so formed would expand and deepen, till they formed the oceans. This is the third crit-

* It would be difficult to discuss with sufficient brevity the probable distribution of these inequalities, but it may be pointed out that the moon is possibly responsible, and that in more ways than one, for much of the existing geographical asymmetry.

ical stage in the history of the earth, dating according to Professor Joly, from between eighty and ninety millions of years ago. With the growth of the oceans the distinction between land and sea arose—in what precise manner we may proceed to inquire. If we revert to the period of the 'consistentior status,' when the earth had just solidified, we shall find, according to Lord Kelvin, that the temperature continuously increased from the surface, where it was 1,170° C., down to a depth of twenty-five miles, where it was about 1,430° C., or 260° C. above the fusion point of the matter, forming a crust. That the crust at this depth was not molten but solid is to be explained by the very great pressure to which it was subjected—just so much pressure, indeed, as was required to counteract the influence of the additional 260° C. Thus if we could have reduced the pressure on the crust we should have caused it to liquefy; by restoring the pressure it would resolidify. By the time the earth's surface had cooled down to 370° C. the depth beneath the surface at which the pressure just kept the crust solid would have sunk some slight distance inwards, but not sufficiently to affect our argument.

The average pressure of the primitive atmosphere upon the crust can readily be calculated by supposing the water of the existing oceans to be uniformly distributed over the earth's surface, and then by a simple piece of arithmetic determining its depth; this is found to be 1.718 miles, the average depth of the oceans being taken at 2.393 miles. Thus the average pressure over the earth's surface, immediately before the formation of the oceans, was equivalent to that of a column of water 1.718 miles high on each square inch. Supposing that at its origin the oceans were all 'gathered together into one place,' and 'the dry land appeared,' then the pressure over the ocean floor would be increased from 1.718 miles to 2.393 miles, while that over those portions of the crust that now formed the land would be diminished by 1.718 miles. This difference in pressure would tend to exaggerate those faint depressions which had arisen under the primitive anti-cyclonic areas, and if the just solidified material of the earth's crust were set into a state of flow, it might move from under the ocean into the bulgings which were rising to form the land, until static equilibrium were established. Under these circumstances the pressure of the ocean would be just able to maintain a column of rock 0.886 miles in height, or ten twenty-sevenths of its own depth. It could do no more; but in order that the dry land may appear some cause must be found competent either to lower the ocean bed the remaining seventeen twenty-sevenths of its full depth, or to raise the continental bulgings to the same extent. Such a cause may, I think, be discovered in a further effect of the reduction in pressure over the continental areas. Previous to the condensation of the ocean, these, as we have seen, were subjected to an atmospheric pressure equal to that of a column of water 1.718 miles in height. This pressure was contributory to that which caused the outer twenty-five miles of the earth's crust to become solid; it furnished, indeed, just about one-fortieth of that pressure, or enough to raise the fusion point 6° C. What, then, might be expected to happen when the continental area was relieved of this load? Plainly a liquefaction and corresponding expansion of the underlying rock.

But we will not go so far as to assert that actual liquefaction would result; all we require for our explanation is a great expansion; and this would probably follow whether the crust were liquefied or not. For there is good reason to suppose that when matter at a temperature above its ordinary fusion point is compelled into the

solid state by pressure, its volume is very responsive to changes either of pressure or temperature. The remarkable expansion of liquid carbon dioxide is a case in point: 120 volumes of this fluid at — 20° C. becomes 150 volumes at 33° C.; a temperature just below the critical point. A great change of volume also occurs when the material of igneous rocks passes from the crystalline stage to that of glass; in the case of diabase* the difference in volume of the rock in the two states at ordinary temperature is 13 per cent. If the relief of pressure over the site of continents were accompanied by volume changes at all approaching this, the additional elevation of seventeen twenty-sevenths required to raise the land to the sea-level would be accounted for.† How far down beneath the surface the unloading of the continents would be felt it is difficult to say, though the problem is probably not beyond the reach of mathematical analysis; if it affected an outer envelope twenty-five miles in thickness, a linear expansion of four per cent. would suffice to explain the origin of ocean basins. If now we refer to the dilatation determined by Carl Barus for rise in temperature in the case of diabase, we find that between 1093° and 1112° C. the increase in volume is 3.3 per cent. As a further factor in deepening the ocean basins may be included the compressive effect of the increase in load over the ocean floor; this increase is equal to the pressure of a column of water 0.675 mile in height, and its effect in raising the fusion point would be 2° C., from which we may gain some kind of idea of the amount of compression it might produce on the yielding interior of the crust. To admit that these views are speculative will be to confess nothing; but they certainly account for a good deal. They not only give us ocean basins, but basins of the kind we want, that is, to use a crude comparison once made by the late Dr. Carpenter, basins of a tea-tray form, having a somewhat flat floor and steeply sloping sides; they also help to explain how it is that the value of gravity is greater over the ocean than over the land.

The ocean when first formed would consist of highly heated water, and this, as is well known, is an energetic chemical reagent when brought into contact with sili-

*C. Barus so names the material on which he experimented; apparently the rock is a fresh dolorite without olivine.

† Professor Fitzgerald has been kind enough to express part of the preceding explanation in a more precise manner for me. He writes: "It would require a very nice adjustment of temperatures and pressures to work out in the simple way you state it; but what is really involved is that in a certain state diabase (and everything that changes state with a considerable change of volume) has an enormous isothermal compressibility. Although this is very enormous in the case of bodies which melt suddenly, like ice, it would also involve very great compressibilities in the case of bodies even which melted gradually, if they did so at all quickly, *i. e.*, within a small range of temperature. What you postulate, then, is that at a certain depth diabase is soft enough to be squeezed from under the oceans, and that, being near its melting point, the small relief of pressure is accompanied by an enormous increase in volume which helped to raise the continents. Now that I have written the thing out in my own way it seems very likely. It is, anyway, a suggestion quite worthy of serious consideration, and a process that in some places must almost certainly have been in operation, and may be is still operative. Looking at it again, I hardly think it is quite likely that there is or could be much squeezing sideways of liquid or other viscous material from under one place to another, because the elastic yielding of the inside of the earth would be much quicker than any flow of this kind. This would only modify your theory, because the diabase that expands so much on the relief of pressure might be that already under the land, and raising up this latter, partly by being pushed up itself by the elastic relief of the inside of the earth and partly by its own enormous expansibility near its melting point. The action would be quite slow, because it would cool itself so much by its expansion that it would have to be warmed up from below, or by tidal earth-squeezing, or by chemical action, before it could expand isothermally.

cates like those which formed the primitive crust. As a result of its action saline solutions and chemical deposits would be formed; the latter, however, would probably be of no great thickness, for the time occupied by the ocean in cooling to a temperature not far removed from the present would probably be included within a few hundreds of years.

THE STRATIFIED SERIES.

The course of events now becomes somewhat obscure, but sooner or later the familiar processes of denudation and the deposition started into activity, and have continued acting uninterruptedly ever since. The total maximum thickness of the sedimentary deposits, so far as I can discover, appears to amount to no less than 50 miles, made up as follows:

Recent and Pleistocene	4,000	...Man.
Pliocene	5,000	...Pithecanthropus.
Miocene	9,000	
Oligocene	12,000	
Eocene	12,000	...Entheria.
Cretaceous	14,000	
Jurassic	8,000	
Trias	13,000	...Mammals.
Permian	12,000	...Reptiles.
Carboniferous	24,000	...Amphibia.
Devonian	22,000	...Fish.
Silurian	15,000	
Ordovician	17,000	
Cambrian	16,000	...Invertebrata.
Keeweenawan	50,000	
Penokee	14,000	
Huronian	18,000	

Geologists, impressed with the tardy pace at which sediments appear to be accumulating at the present day, could not contemplate this colossal pile of strata without feeling that it spoke of an almost inconceivably long lapse of time. They were led to compare its duration with the distances which intervene between the heavenly bodies; but while some chose the distance of the nearest fixed star as their unit, others were content to measure the years in terms of miles from the sun.

EVOLUTION OF ORGANISMS.

The stratified rocks were eloquent of time, and not to the geologist alone; they appealed with equal force to the biologist. Accepting Darwin's explanation of the origin of species, the present rate at which form flows to form seemed so slow as almost to amount to immutability. How vast then must have been the period during which by slow degrees and innumerable stages the protozoon was transformed into the man! And if we turn to the stratified column, what do we find? Man, it is true, at the summit, the oldest fossiliferous rocks 34 miles lower down, and the fossils they contain already representing most of the great classes of the Invertebrata, including Crustacea and Worms. Thus the evolution of the Vertebrata alone is known to have occupied a period represented by a thickness of 34 miles of sediment. How much greater, then, must have been the interval required for the elaboration of the whole organic world! The human mind, dwelling on such considerations as these, seems at times to have been affected by a sur-excitation of the imagination, and a consequent paralysis of the understanding, which led to a refusal to measure geological time by years at all, or to reckon by anything less than 'eternities.'

GEOLOGIC PERIODS OF TIME.

After the admirable address of your President last year it might be thought needless for me to again enter into a consideration of this subject; it has been said, however, that the question of geological time is like the Djin in Arabian tales, and will irrepressibly come up again for discussion, however often it is disposed of. For my part I do not regard the question so despondingly, but rather hope that by persevering effort we may succeed in discovering the talisman by which we may compel the unwilling Djin into our service. How

immeasurable would be the advance of our science could we but bring the chief events which it records into some relation with a standard of time!

Before proceeding to the discussion of estimates of time drawn from a study of stratified rocks let us first consider those which have been already suggested by other data. These are as follows: (1) Time which has elapsed since the separation of the earth and moon, fifty-six millions of years, minimum estimate by Professor G. H. Darwin. (2) Since the 'consistentior status,' twenty to forty millions (Lord Kelvin). (3) Since the condensation of the oceans, eighty to ninety millions, maximum estimate by Professor J. Joly.

It may be at once observed that these estimates, although independent, are all of the same order of magnitude, and so far confirmatory of each other. Nor are they opposed to conclusions drawn from a study of stratified rocks; thus Sir Archibald Geikie, in his address to this Section last year, affirmed that, so far as these were concerned, one hundred millions of years might suffice for their formation. There is then very little to quarrel about, and our task is reduced to an attempt, by a little stretching and a little paring, to bring these various estimates into closer harmony.

Professor Darwin's estimate is admittedly a minimum; the actual time, as he himself expressly states, 'may have been much longer.' Lord Kelvin's estimate, which he would make nearer twenty than forty millions, is founded on the assumption that since the period of the 'consistentior status' the earth has cooled simply as a solid body, the transference of heat from within outwards having been accomplished solely by conduction.*

It may be at once admitted that there is a large amount of truth in this assumption; there can be no possible doubt that the earth reacts towards forces applied for a short time as a solid body. Under the influence of the tides it behaves as though it possessed a rigidity approaching that of steel, and under sudden blows, such as those which give rise to earthquakes, with twice this rigidity, as Professor Milne informs me. Astronomical considerations lead to the conclusion that its effective rigidity has not varied greatly for a long period of past time.

Still, while fully recognizing these facts, the geologist knows—we all know—that the crust of the earth is not altogether solid. The existence of volcanoes by itself suggests the contrary, and although the total amount of fluid material which is brought up from the interior to the exterior of the earth by volcanic action may be, and certainly is, small—from data given by Professor Penck, I estimate it as equivalent to a layer of rock uniformly distributed 2 mm. thick per century; yet we have every reason to believe that volcanoes are but the superficial manifestation of far greater bodies of molten material which lie concealed beneath the ground. Even the wide areas of plutonic rock, which are sometimes exposed to view over a country that has suffered long-continued denudation, are merely the upper portion of more extensive masses which lie remote from view. The existence of molten material within the earth's crust naturally awakens a suspicion that the process of cooling has not been wholly by conduction, but also to some slight extent by convection, and to a still greater extent by the bodily migration of liquid lava from the deeper layers of the crust towards the surface.

The existence of local reservoirs of molten rock within the crust is even still more important in another connection, that is, in relation with the supposed 'average rate of increase of temperature with descent below

*The heat thus brought to the surface would amount to one-seventeenth of that conveyed by conduction.

the ground.' It is doubtful whether we have yet discovered a rate that in any useful sense can be spoken of as 'average.' The widely divergent views of different authorities as to the presumed value of this rate may well lead to reflection. The late Professor Prestwich thought a rise of 1° F.

FIG. 1.—Map of the British Isles, showing the distribution of rates of increase of temperature with descent. The rates are taken from the 'British Association Report,' except in the case of those in the south of Ireland.

for every 45 feet of descent below the zone of constant temperature best represented the average; Lord Kelvin in his earliest estimates has adopted a value of 1° F. for every 51 feet; the committee of this association appointed to investigate this question arrived at a rate of 1° F. for every 60 feet of descent; Mr. Clarence King has made calculations in which a rate of 1° F. for 72 feet is adopted; a re-investigation of recorded measurements would, I believe, lead to a rate of 1° F. in 80 or 90 feet as more closely approaching the mean. This would raise Lord Kelvin's estimate to nearly fifty millions of years.

When from these various averages we turn to the observations on which they are based, we encounter a surprising divergence of extremes from the mean; thus in the British Isles alone the rate varies from 1° F. in 34 feet to 1° F. in 92 feet, or in one case to 1° F. in 130 feet. It has been suggested, and to some extent shown, that these irregularities may be connected with differences in conductivity of the rocks in which the observations were made, or to the circulation of underground water; but many cases exist which cannot be explained away in such a manner, but are suggestive of some deep-seated cause, such as the distribution of molten matter below the ground. Inspection of the accompanying map of the British Isles, on which the rates of increase in different localities have been plotted, will afford some evidence of the truth of this view. Comparatively low rates of increase are found over Wales and in the province of Leinster, districts of relatively great stability, the remnants of an island that have in all probability stood above the sea ever since the close of the Silurian period. To the north of this, as we enter a region which was subject to volcanic disturbances during the Tertiary period, the rate increases.

It is obvious that in any attempt to estimate the rate at which the earth is cooling as a solid body the disturbing influence of subterranean lakes of molten rock must as far as possible be eliminated; but this will not be effected by taking the accepted mean of observed rates of increase of tempera-

ture; such an average is merely a compromise, and a nearer approach to a correct result will possibly be attained by selecting some low rate of increase, provided it is based on accurate observations.

It is extremely doubtful whether an area such as the British Isles, which has so frequently been the theater of volcanic activity and other subterranean disturbance, is the best fitted to afford trustworthy results; the Archæan nucleus of a continent might be expected to afford surer indications. Unfortunately the hidden treasures of the earth are seldom buried in these regions, and bore-holes in consequence have rarely been made in them. One exception is afforded by the copper-bearing district of Lake Superior, and in one case, that of the Calumet and Hecla mine, which is 4,580 feet in depth, the rate of increase, as determined by Professor A. Agassiz, was 1° F. for every 223.7 feet. The Bohemian 'horst' is a somewhat ancient part of Europe, and in the Przibian mines, which are sunk in it, the rate was 1° F. for every 126 feet of descent. In the light of these facts it would seem that geologists are by no means compelled to accept the supposed mean rate of increase of temperature with descent into the crust as affording a safe guide to the rate of cooling of a solid globe; and if the much slower rate of increase observed in the more ancient and more stable regions of the earth has the importance which is suggested for it, then Lord Kelvin's estimate of the date of the 'consistentior status' may be pushed backwards into a remoter past.

If, as we have reason to hope, Lord Kelvin's somewhat contracted period will yield to a little stretching, Professor Joly's on the other hand, may take some paring. His argument, broadly stated, is as follows: The ocean consisted at first of fresh water; it is now salt, and its saltness is due to the dissolved matter that is constantly being carried into it by rivers. If, then, we know the quantity of salt which the rivers bring down each year into the sea, it is easy to calculate how many years they have taken to supply the sea with all the salt it at present contains. For several reasons it is found necessary to restrict attention to one only of the elements contained in sea salt: this is sodium. The quantity of sodium delivered to the sea every year by the rivers is about 160,000,000 tons; but the quantity of sodium which the sea contains is at least ninety millions of times greater than this. The periods during which rivers have been carrying sodium into the sea must, therefore, be about ninety millions of years. Nothing could be simpler; there is no serious flaw in the method, and Professor Joly's treatment of the subject is admirable in every way; but of course in calculations such as this everything depends on the accuracy of the data, which we may, therefore, proceed to discuss. Professor Joly's estimate of the amount of sodium in the ocean may be accepted as sufficiently near the truth for all practical purposes. We may, therefore, pass on to the other factor, the annual contribution of sodium by river water. Here there is more room for error. Two quantities must be ascertained: one the quantity of water which the rivers of the world carry into the sea, the other the quantity or proportion of sodium present in this water. The total volume of water discharged by rivers into the ocean is estimated by Sir John Murray as 6,524 cubic miles. The estimate being based on observations of thirty-three great rivers although only approximate, it is no doubt sufficiently exact; at all events such alternations as it is likely to undergo will not greatly affect the final result. When, however, we pass to the last quantity to be determined, the chemical composition of average river water, we find that only a very rough estimate is possible, and this is the more unfortunate because changes in this may

very materially affect our conclusions. The total quantity of river water discharged into the sea is, as we have stated, 6,524 cubic miles. The average composition of this water is deduced from analyses of nineteen great rivers, which altogether discharge only 488 cubic miles, or 7.25 per cent. of the whole. The danger in using this estimate is two-fold: in the first place 7.25 is too small a fraction from which to argue to the remaining 92.75 per cent., and next, the rivers which furnish it are selected rivers, *i. e.*, they are all of large size. The effect of this is that the drainage of the volcanic regions of the earth is not sufficiently represented, and it is precisely this drainage which is richest in sodium salts. The lavas and ashes of active volcanoes rapidly disintegrate under the energetic action of various acid gases, and among volcanic exhalations sodium chloride has been especially noticed as abundant. Consequently we find that while the proportion of sodium in Professor Joly's average river water is only 5.73 per million, in the rivers of the volcanic island of Hawaii it rises to 24.5 per million (Walter Maxwell, 'Lavas and Soils of the Hawaiian Islands,' p. 170). No doubt the area occupied by volcanoes is trifling compared with the remaining land surface. On the other hand the majority of volcanoes are situated in regions of copious rainfall, of which they receive a full share owing to their mountainous form. Much of the fallen rain percolates through the porous material of the cone, and, richly charged with alkalies, finds its way by underground passages towards the sea, into which it sometimes discharges by submarine springs.

Again, several considerations lead to the belief that the supply of sodium to the ocean has proceeded, not at a uniform, but at a gradually diminishing rate. The rate of increase of temperature with descent into the crust has continuously diminished with the flow of time, and this must have had its influence on the temperature of springs, which furnish an important contribution to river water. The significance of this consideration may be judged from the composition of the water of geysers. Thus Geyser, in Iceland, contains 884 parts of sodium per million, or nearly 160 times as much as Sir John Murray estimates is present in average river water. A mean of the analyses of six geysers in different parts of the world gives 400 parts of sodium per million, existing partly as chloride, but also as sulphate and carbonate.

It should not be overlooked that the present is a calm and quiet epoch in the earth's history, following after a time of fiery activity. More than once, indeed, has the past been distinguished by unusual manifestations of volcanic energy, and these must have had some effect upon the supply of sodium to the ocean. Finally, although the existing ocean water has apparently but slight effect in corroding the rocks which form its bed, yet it certainly was not inert when its temperature was not far removed from the critical point. Water begins to exert a powerful destructive action on silicates at a temperature of 180° C., and during the interval occupied in cooling from 370 to 180° C. a considerable quantity of sodium may have entered into solution.

A review of the facts before us seems to render some reduction in Dr. Joly's estimate imperative. A precise assessment is impossible, but I should be inclined myself to take off some ten or thirty millions of years.

We may next take the evidence of the stratified rocks. Their total maximum thickness is, as we have seen, 265,000 feet, and consequently if they accumulated at the rate of one foot in a century, as evidence seems to suggest, more than twenty-six millions of years must have elapsed during their formation. W. J. Sollas.

(To be concluded.)

*THE GEOLOGICAL AND PALEONTOLOGICAL COLLECTIONS IN THE AMERICAN MUSEUM OF NATURAL HISTORY.**

THIS informal paper was prepared by the author (in the absence of Professor R. P. Whitfield, who has been curator of the Geological Department of the Museum for more than twenty-three years) at the request of the officers of Section E, so that members in attendance at the meeting of the Association might know in a general way what to look for on visiting the Museum.

The first series of valuable fossils to be acquired by the American Museum of Natural History was the Holmes collection from the Tertiary deposits of South Carolina. This included the types of the species described in Tuomey and Holmes' works.† The second important series to be put on exhibition was the set of eight mounted skeletons of moas from New Zealand, constituting the De Haas types of those birds. There are eight unmounted skeletons in the same collection, thirteen species being represented in all.

The main portion of the department's specimens is composed of the James Hall collection, the acquisition of which in 1875 placed the Museum in the lead among American institutions in respect to Paleozoic fossils, on account of the great number of types and figured specimens contained therein, such specimens being numbered by the thousand.‡ Especially noteworthy in the Hall collection, aside from the wonderfully rich New York series, are the Potsdam fossils from Minnesota and Wisconsin; Trenton forms from Wisconsin and Iowa, the unfigured types of which have been republished by Professor Whitfield with figures in the Memoirs of the Museum; Niagara fossils from Waldron, Indiana; corals from the Falls of the Ohio river; crinoids from Burlington, Iowa, and the remarkable Lower Carboniferous fauna of Spergen Hill, Indiana, both of which last have been republished by Professor Whitfield with figures from the original types, the former in the Memoirs and the latter in the Bulletin of the Museum.

Other collections which may be mentioned are the Chazy and Fort Cassin fossils from the vicinity of Lake Champlain, containing types which have been described by Professor Whitfield in the Bulletin of the Museum; a complete set of the Vermont and New Hampshire rocks illustrating the geological survey of those States by Professor C. H. Hitchcock, and the types of the Tertiary plants from Brandon, Vermont; an excellent series of Paleozoic fossils from Illinois and neighboring States; fossils from the Cretaceous marls of New Jersey, collected and presented to the Museum by Professor Whitfield, and fine sets of fish remains from the Triassic of the Connecticut valley and the Tertiary beds of Wyoming. The most recent noteworthy addition is one of the Tyrrell collections of placoderm fishes from the Devonian rocks of Ohio.

The arrangement of the collection is that devised by Professor Whitfield when he came to the Museum, and it is worthy of careful consideration on account of the way it has stood the test of time and use. Beginning at the northeast corner of the hall (because that is beside what was originally the only entrance to the room and was understood to be the permanent main entrance thereto) the specimens are arranged stratigraphically in ascending geological order. Under the stratigraphic arrangement, the grouping is by geographical or lithological provinces, first New York, or eastern and

* Read before Section E of the American Association for the Advancement of Science, June 26, 1900.

† Pleiocene Fossils of South Carolina, by M. Tuomey and F. S. Holmes. 4to. Charleston, S. C., 1857; Post-Pleiocene Fossils of South Carolina, by F. S. Holmes. 4to. Charleston, S. C., 1860.

‡ Published principally in the reports of the State Geological Surveys of New York, Iowa, Wisconsin and Indiana.

then western. Under this again the arrangement is strictly biological, beginning with plants, where present, and then taking the animals in ascending scale. This scheme has been carried out most definitely in the upright cases, while the desk cases contain many of the best specimens and fit into the classification as well as is practicable. A part of each of twelve of the desk cases is occupied by specimens comprising the Dana's Manual series. These illustrate the figures in that standard work on geology and form an epitome of the historical side of the science. Many of the figures are represented by the very specimens from which the originals were drawn. Large specimens showing ripple marks, footprints, concretions, and other phenomena are placed on the tops of the cases and in other places out of series.

A very valuable feature of the installation is that of separating the biological units from one another, so that the individuals, species, genera, families, etc., which belong together can be distinguished on the most rapid inspection. This is effected by means of narrow strips of wood of different colors placed between the trays holding the fossils, single black strips separating different species, red ones genera, white ones families, two white ones limiting orders and two black denoting the boundaries of classes and higher subdivisions. The specimens, furthermore, are arranged so that one naturally examines them from left to right and from below upwards, except that the upper shelves of the upright cases are occupied by large and small specimens showing the grouping of the fossils in the rocks and the geological features of the beds. More than nine-tenths of the hall is devoted to the American forms, the rest being given up to a synoptic series of European fossils and fossils from other foreign localities.

The mineral collection, which is under the immediate care of Mr. L. P. Gratacap, has grown to large proportions and well repays careful study. About five hundred species are represented by nearly ten thousand specimens which are arranged according to the sixth edition of Dana's System of Mineralogy. The specialty of an institution like the American Museum is large, showy specimens, and we have a great many such which are worthy the notice of the scientific as well as the popular visitor. Especially conspicuous among these are specimens of quartz, gypsum, barite, calcite and fluorite, but above all the unrivaled malachites, azurites and stalactites from the Copper Queen Co.'s mines at Bisbee, Arizona. The collection of gems and gem material, too, should not be overlooked, since it contains many unique and beautiful specimens.

The Museum collections of the fossil remains of mammals and reptiles are in the Department of Vertebrate Paleontology, and being thus outside of my province, I refer to them with the permission of the curator of the department, Professor Henry F. Osborn. The exhibition series is to be found in the hall of the east wing of the Museum building, on the same floor with the collections of the Geological Department, and it includes many wonderful specimens, the like of which are to be found in no other institution in the world. The department was organized and the work of collecting begun in the year 1891 with Professor H. F. Osborn as curator, Dr. J. L. Wortman as assistant curator in charge of the field work, and Adam Hermann as head preparator. Thanks to the ability and energy of this corps of workers and their assistants, the collection has grown with great rapidity and substantiality, while the installation is a model.

The amount of exhibition material on hand and mounted in 1895 was sufficient to warrant the opening of the hall, and the public obtained the first view of these col-

lections in October of that year. One of the constant aims of the curator has been to obtain complete skeletons for the exhibition cases; and an inspection of the cases will show the extent to which this aim has been attained. Pains and expense have not been spared in the effort to make the collection attractive in appearance, as well as useful to the student. The primary idea in the arrangement of this collection is to show the evolution of the various types of animals represented, while the geological association is secondary. Thus on the south side of the room we have the perissodactyls, beginning with the titanotheres and passing on through the tapirs, lophiodonts, rhinoceroses and paleotheres to the horses. On the north side of the room, and beginning, as before, at the west end of the hall, we have the amblypods (pantolambdas, coryphodonts and uintatheres), the elotheres, the oreodonts and the ancestors of the llamas and the camels.

Among the sets just mentioned are some specimens that deserve more than the passing notice that can be given them here. Cope's type specimen of *Phenacodus primævus*, the collateral ancestor of the hoofed animals, was acquired with the purchase of that famous scientist's collection of fossil mammals in 1895. It has been worked out of the matrix since it came to the Museum and mounted, so that every bone on one side can be removed readily for the purpose of examination or study. *Hophlophoneus primævus* Leidy, the ancient saber-toothed tiger, is represented by an absolutely complete skeleton, even the smallest bones of the tail having been preserved. This, too, has been mounted so that every bone can be readily removed for study. *Patriofelis ferox* Marsh, the ancient aquatic tiger-cat, *Coryphoden testis* Cope and *Palæosyops paludosus* Leidy are represented by specimens which are almost equally good. An immense Titanotherium skeleton, which has been made up from but two individuals, shows an interesting fracture of one of the ribs on the right side which was healed during the life of the beast. Four rhinosceros skeletons show the long-legged, agile and short-legged, sluggish types. These have been described by Professor Osborn in a Memoir of the Museum. The bones of one of these skeletons are so perfect that they hardly look like fossils. The evolution of the horse is represented by a series of skulls as well as by the more familiar series of leg bones.

The subject of reptiles is now receiving much attention and some remarkable specimens have been placed on exhibition, the most noteworthy of which is the nearly entire skeleton of a mosasaur (*Tylosaurus dispelor* (Cope)) from the Upper Cretaceous of Kansas. The individual must have been originally more than thirty feet in length. About twenty-eight feet of it have been preserved in this specimen, which has been mounted in the original matrix in which it was found and placed in a shallow case against the wall near the entrance to the hall. *Diplodocus*, *Camarasaurus* and other herbivorous and carnivorous dinosaurs from the western Jurassic and Cretaceous beds are represented in the cases by sets of vertebræ, pelvic bones, ribs and legs which give the visitor a very good idea of the immense size and the proportions of these ancient lizards.

In 1895 the mammal remains in Professor Cope's famous collection were purchased by the Museum, and in 1898 the remainder of his collection was acquired. These acquisitions brought to the Museum a large number of invaluable type specimens and established the position of the institution as one of the most important, if not the most important, place in the world for the study of vertebrate paleontology. Aside from these types, the collection contains, as a matter of course, all the material de-

scribed and illustrated in the Bulletins and Memoirs of the Museum by Messrs. Osborn, Wortman, Matthew (W. D.), and Earle.

A description of this department of the Museum would be very incomplete without mention of the life-like water-color restorations of mammals and reptiles which have been made by Charles R. Knight, under the direction and with the advice and assistance of Professors Osborn, Cope and Scott. These pictures are, without question, the best attempts that have ever been made to represent the animal life and the scenery of Mesozoic and Cenozoic time in this country or Europe. The collection is very thoroughly labeled, with elaborate descriptive as well as individual labels and photographic transparencies of many of the western fossiliferous localities occupy some of the windows.

Edmund Otis Hovey.

SCIENTIFIC BOOKS.

Evolution by Atrophy in Biology and Sociology. By Jean Demoor, Agrégé of the Free University of Brussels; Jean Massart, Chargé de Cours of the Free University of Brussels; Emile Vandervelde, Professor at the Institute des Hautes Études of Brussels, translated by Mrs. Chalmers Mitchell. The International Scientific Series. New York, D. Appleton & Co. 1899.

An eminent American economist has declared the bankruptcy of biological sociology. The authors of 'Evolution of Atrophy,' have assumed the receivership of a section of biological sociology, namely, that dealing with degeneration. Realizing that "biosociological investigations have hitherto been conducted either by naturalists with a limited knowledge of social questions, or by sociologists whose training was incomplete and superficial," their researches on degeneration "have been made separately from the social side and from the biological side, and have now been coordinated and combined." The volume is divided into three books, dealing respectively with 'Universality of degenerative evolution,' 'The path of degenerative evolution,' and 'Causes of degenerative evolution.' Each book is divided into three parts, the third of which gives a summary and conclusions of the first two. The result of the collaboration of several authors has resulted in a well-systematized arrangement of topics and an attempt at balancing a part, chapter, or section in Biology with a similar one in Sociology. Thus Part I. of Book I. deals with 'Degeneration in the development of institutions and organs.' Chapter I. 'In the evolution of organs all modification is necessarily attended by degeneration.' Chapter II. 'In the evolution of institutions all modification is necessarily accompanied by degeneration,' and of Part I., Chapter I., 'All organisms exhibit rudimentary organs.' Chapter II. 'Survivals exist in all kinds of societies.' Or in Book II., Part II., Chapter I., we have: *Section I.* 'Disappeared organs.' *Section II.* 'Disappeared institutions.' There is thus a constant interlarding of fat with lean.

Book I. is essentially a statement of facts from which the authors conclude that "degenerative evolution exists everywhere * * * in the evolution of organs certain facts may disappear completely * * * in the evolution of organisms certain organs may also disappear. * * * Not only may a larval stage or an adult stage be completely suppressed, but a multicellular organism may even lose its power of dying." Degeneration is not an accident and is not confined to unusual, abnormal or pathological cases. Living and superior civilizations drag behind them a trail of débris from dead civilizations.

Book II. is an examination of the question whether the degeneration of individuals and of organs proceeds by successive atrophies occurring in the order opposite to that of ontological formation. In considering the series of pineal eyes offered by various animals they "cannot refrain from the conclusion that in this series degeneration retraces to a large extent the steps of original advance." This, however, is not a universal application, and "although the most recently acquired features may disappear first, degeneration is not an actual retracing of steps until the point of departure is reached. The degenerate condition is a new point, and really the term retrogres-

sive evolution is misleading." "Rudimentary organs and institutions resemble the primitive states of these, in so far as they no longer possess certain parts which the primitive stages did not yet possess. None the less profound differences exist between the primitive and the reduced forms." This difference lies largely in the difference of potentiality of the primitive and the degenerate organ to vary in the direction of new uses. "After a certain degree of atrophy, there is no longer the possibility of re-development to resume old or to acquire new functions."

The Degeneration is in Book III. attributed to (1) lack of space; (2) lack of use; (3) lack of nutrition, as in the genitalia of neuter bees; (4) atrophy without apparent cause. If a functionless organ persists it is because neither variation nor selection has intervened. The struggle for existence between the various organs and the struggle for existence between various organisms are in the opinion of these authors 'the principal if not the sole agents in degeneration,' while inutility of function, insufficiency of nutriment or resource, and lack of space are occasional causes of degenerative evolution.

The book is written in a popular and entertaining style.

C. H. EIGENMANN.

Sounding the Ocean of Air. By A. LAWRENCE ROTCH, S.B., A.M. Romance of Science Series. London, Society for Promoting Christian Knowledge, and New York, E. and J. B. Young. 1900. Small 8vo. Pp. 184. $1.00.

The work in kite meteorology carried on during the past six years at Blue Hill Observatory under the direction and through the liberality of Mr. A. Lawrence Rotch needs no introduction to the readers of SCIENCE. Mr. Rotch's pioneer work in scientific kite-flying has received the stamp of official approval at the hands of the International Meteorological Conference and of the International Aeronautical Committee, and similar investigations have lately been begun at several of the European meteorological observatories. 'Sounding the Ocean of Air' is the attractive title of a little book, issued in the Romance of Science Series, which comprises six lectures delivered by the author before the Lowell Institute of Boston, in December, 1898. The subjects dealt with in the six chapters are 'The Atmosphere'; 'Clouds'; 'Balloons'; 'Ballons-sondes for Great Altitudes'; 'Kites,' and 'Results of Kite-Flights at Blue Hill.' The whole volume presents a clear and systematic account of the history and present status of the exploration of the free air. The last chapter, on the 'Results of the Kite-Flights at Blue Hill,' gives a useful summary, almost too condensed for understanding without careful study, of the notable results obtained by Mr. H. H. Clayton, of the Blue Hill Observatory staff, from the records made by the kite meteorograph. This chapter will, therefore, probably have the greatest interest for meteorologists, although the chapter on Clouds, in which the Blue Hill cloud work is given special attention, is hardly less important. This little book is to be recommended to all who wish to inform themselves concerning the work that is now being done in 'sounding the ocean of air,' as Mr. Rotch has happily phrased it. The volume emphasizes once again the high scientific quality of the work done by Messrs. Clayton, Fergusson and Sweetland, under Mr. Rotch's direction, at Blue Hill Observatory. The dedication is so appropriate as to deserve quotation here: "This little Book is gratefully dedicated to the late Augustus Lowell, Esq., of Boston, U. S. A., who, as Trustee of the Lowell Institute, enabled Scientific Men of Two Continents to present the Results of their Investigations to the Public."

R. DEC. WARD.

HARVARD UNIVERSITY.

Free-hand Perspective. By VICTOR T. WILSON. New York and London, Wiley and Sons; Chapman & Hall. 1900. 8vo. Pp. xii + 257. Ill., 139.

This is a work intended for use in a section of the free-hand classes of the drawing departments of technical schools and in similarly appropriate work. It is seldom that the writer of a book of this class can now expect to bring out anything essentially original in either matter or manner, or treatment generally. In this case, however, original genius has found expression, and we discover in Mr. Wilson's book some entirely new and very valuable matter;

while the system and tone of the discussion are characteristic of the expert in this department.

In consequence of the fact that the free-hand classes are usually formed before the student has studied descriptive geometry, the writer of this work had found it necessary to give him some introductory work in that branch, and it thus furnishes a valuable series of exercises introductory to the more formal treatment of that subject later. The book is, in fact, a discussion of the principles of linear perspective as employed in free-hand sketching. The illustrations throughout the book are especially interesting as being *fac simile* reproductions of such actual sketches, made with a free hand, in the course of regular class work. The departure from the absolute perfection of line obtainable with instruments is clearly observable; but the accuracy of these lines, rectilinear and curvelinear, made by the unaided hand, is a beautiful illustration of the nicety with which the senses may be developed in this field. A comparison of Fig. 126 with the immediately succeeding sketches, all of which are of peculiar interest, illustrates this point. Nearly all the illustrations are curiously perfect, in line and in tone, as illustrative of free hand work.

The last chapter, 'Sketches from Working Drawings,' involves the most original of the author's inventions and the most helpful, to the student of mechanism. The methods of sketching from simple drawings are indicated and examples given, the principles of location of line and angle and plane are shown very clearly and a system is developed for the production of a perspective drawing of the object when the only data available are to be obtained from the ordinary plan and elevation of the working drawing of the shop. The perfection and the extensive applicability of this new system are well exhibited in the progression from Fig. 111 to Fig. 114, in which a steam-engine crosshead is thus treated; in Fig. 118 and Fig. 119, in illustration of a complicated casting for an engine-bed, and even more remarkably in Figs. 133–136, where a very difficult form of beam and bell-crank for a pumping engine is brought out. The teaching of this new art, to the young engineer, particularly, is likely to give him great facility in the reverse process of reading the working drawing, and it must prove very helpful; especially, where he is compelled to explain to the workman drawings of peculiar or complicated forms, and shapes difficult to picture in the mind's eye, as the pattern-maker and the finisher must picture every piece on which he is to work and with no other aid to his imagination than the plans and elevation of the working drawings.

Mr. Wilson has made a distinct advance in his art, an invention of striking interest, one probably of no small value.

R. H. Thurston.

Our New Prosperity. By Ray Stannard Baker. New York, Doubleday & McClure Co. 1900. 12mo., pp. 267; many illustrations. Price, $1.50.

There is a class of books, illustrated by Carnegie's 'Triumphant Democracy,' Wright's 'Industrial Evolution of the United States,' Gannett's 'Building of a Nation,' and Dr. Strong's 'Our Country,' which should interest, absorbingly interest, every thinking man, especially every American citizen, and still more especially every young man. To this class belongs Mr. Baker's new book. It is a condensed and very impressive statement, based upon official statistics, of the conditions which have brought about the present extraordinary flood of prosperity in all industrial departments in this country, the good results that followed the trying period of 'hard times' of earlier years in the clearing off of old scores and reduction of the business of the country to a solid basis, the effects of the 'prosperity wave' at home and abroad, the development of the industries of the New South, the 'invasion of the world' by the exporters and manufacturers of the United States, and glances at the prognostications of a future, not likely to be free from trouble and an occasional retrogression, but on the whole one of enormous promise, and apparently of certain rise to as yet unimagined greatness. The statistical matter, which constitutes the main and fundamental portion of the work, comes from the Treasury Department bureaux, those of the Mint, the Labor Commissioner, the Geological Survey and the various other departments at Washington, with acces

sions from the technical journals and from many experts among business men.

R. H. THURSTON.

GENERAL.

MESSRS. GAUDRY AND BARROIS and their confrères in France have brought out in the form of a guide-book to the geological excursions undertaken this summer under the auspices of the International Congress of Geologists, a veritable hand-book of the geology of France, entitled 'Livret-guide des Excursions en France du VIII^e Congrès Géologique Internalional.' The work is beautifully illustrated with reproductions from photographs, with cuts of sections and colored maps, making the collection of papers on the different geological provinces of the Republic by far the most complete publication of the kind for any country. The matter is presented in such a form that it will serve the reader as well as the geological traveler. Paper and press-work are of the best quality.

J. B. W.

IN the first part of his work 'Ueber Museen des Ostens der Vereinigten Staaten von Nord Amerika,' Dr. A. B. Meyer, the director of the Dresden Museum, describes the museums of New York City, Albany and Buffalo.

BOOKS RECEIVED.

Status of the Mesozoic Floras of the United States. LESTER F. WARD, with the corroboration of WM. M. FONTAINE, ATREUS WANNER and F. H. KNOWLTON. Washington, Government Printing Office. 1900. Pp. 213–430. Plates XXI–CXLIV.

A Practical Course in Mechanical Drawing. WILLIAM FOX and CHARLES W. THOMAS. New York, D. Van Nostrand Co. 1899. Pp. vi + 98.

Chemical Technology. Edited by C. E. GROVES and WILLIAM THORP, Vol. III. *Gaslighting.* CHARLES HUNT. Philadelphia, P. Blakiston's Son & Co. 1900. Pp. xviii + 312.

SCIENTIFIC JOURNALS AND ARTICLES.

The Botanical Gazette, October, contains an important paper by Dr. R. A. Harper, of the University of Wisconsin, on 'Cell and Nuclear Division in *Fuligo varians*,' a common slime mold. The results have led Dr. Harper to discuss in a general way the processes of cell division, and he discovers no such definite rules of cleavage as have been urged by authors. Mr. W. J. G. Land, of the Hull Botanical Laboratory, describes cases of double fertilization in *Erigeron* and *Silphium*, in both of which cases he discovered the second male cell conjugating with the endosperm nucleus or with one of the polar nuclei. The male cells of *Silphium* are remarkable in that they are much elongated and spirally coiled. Miss Mary Hefferan, of the Bacteriological Laboratory of the University of Chicago, describes 'A New Chromogenic Micrococcus,' discovered in the course of an examination of river water for the Sanitary District of Chicago. Mr. E. R. Hodson, of the Iowa Agricultural College, describes 'A New Species of *Neovossia*,' a smut affecting the ovaries of *Phragmites communis*. Mr. Henry Kraemer, of the Philadelphia College of Pharmacy, writes concerning the origin of tannins in galls, coming to the conclusion that the crystalline compound found in the galls which he examined is gallic acid, which becomes transformed into tannin.

The Auk, for October, has for its first article an account of 'A Nuptial Performance of the Sage Cock,' with a plate showing how the bird slides along on its breast with distended air sacs. J. A. Allen discusses 'Aptosochromatism,' reviewing the most recent articles on alleged change of color in feathers without moult, changes which Dr. Allen does not consider as taking place. James J. Carroll presents 'Notes on the Birds of Refugio County, Texas,' giving a list of 185 species, and William H. Kobbé in 'The Birds of Cape Disappointment, Washington,' gives an annotated list of 63 species. W. E. Saunders describes the 'Nesting Habits of the Cerulean Warbler.' J. A. Allen under 'North American Birds Collected at Santa Marta, Colombia,' presents a list of 43 species. Finally Jonathan Dwight, Jr., makes another of his important contributions to ornithology in 'The Moult of the North American Shore Birds (*Limicolæ*),' which has a very direct bearing on the question of change of color without moult. Dr. Dwight emphatically states that changes of color in plumage are the results of moulting and wear. There are the customary General Notes and Reviews of Recent Litera-

ture, and the number contains the Index to Volume XVII. It is noted that hereafter *The Auk* will be published by Edward W. Wheeler, 30 Boylston Street, Cambridge, Mass.

THE October number (Volume 7, No. 1) of the *Bulletin of the American Mathematical Society* contains the following articles: Report of the recent summer meeting of the Society, by the Secretary; 'The Undergraduate Mathematical Curriculum,' report of the discussion at the Summer Meeting, by Professor W. H. Maltbie; 'On a Memoir by Ricardo de Paolis,' by Professor Charlotte Angas Scott; 'Notes'; and 'New Publications.' The November number of the *Bulletin* contains: 'The International Congress of Mathematicians in Paris,' report by Professor Charlotte Angas Scott; 'The Forty-ninth Annual Meeting of the American Association for the Advancement of Science,' report of the meeting of Section A, by Dr. G. A. Miller; 'Note on Geometry of Four Dimensions,' by Professor E. O. Lovett; 'Notes'; and 'New Publications.'

The October (closing) number of Volume 1 of the *Transactions of the American Mathematical Society* contains the following papers: 'On Surfaces enveloped by Spheres belonging to a Linear Spherical Complex,' by P. F. Smith; 'On Certain Relations among the Theta Constants,' by J. I. Hutchinson; 'On the Groups which have the same Group of Isomorphisms,' by G. A. Miller; 'Die Hesse'sche und die Cayley'sche Curve,' by P. Gordan; 'Application of a Method of D'Alembert to the Proof of Sturm's Theorems of Comparison,' by M. Bôcher; 'Two Plane Movements Generating Quartic Scrolls,' by E. M. Blake; 'The Invariant Theory of the Inversion Group: Geometry upon a Quadric Surface,' by E. Kasner; 'A Simple Proof of the Fundamental Cauchy-Goursat Theorem,' by E. H. Moore; 'Notes and Errata,' Volume I.

CAMBRIDGE UNIVERSITY press will begin on the first of January next the publication of a quarterly *Journal of Hygiene*, to be edited by Dr. G. H. F. Nuttall, Lecturer in Bacteriology and Preventive Medicine in the University of Cambridge, Dr. John Haldane, F.R.S., Lecturer in Physiology in the University of Oxford, and Dr. Arthur Newsholme, M. O. H., Brighton.

SOCIETIES AND ACADEMIES.

AMERICAN MATHEMATICAL SOCIETY.

A REGULAR meeting of the American Mathematical Society was held at Columbia University, New York City, on Saturday, October 27, 1900. Professor Thomas S. Fiske, Vice-President of the Society, occupied the chair during the two sessions. The total attendance amounted to thirty-two, including twenty-five members of the Society.

The Council announced the election of the following persons to membership in the Society: Professor George L. Brown, South Dakota Agricultural College, Brookings, So. Dak.; Mr. Charles H. Davis, New York, N. Y.; Dr. Derrick N. Lehmer, University of California, Berkeley, Cal.; Miss Ida M. Schottenfels, Chicago, Ill.; Professor Frank D. Sherman, Columbia University, New York, N. Y.; Mr. Burke Smith, Northwestern University, Evanston, Ill. Twenty-five applications for admission to membership were received.

In response to the invitation of Cornell University the Summer Meeting and Colloquium of the Society will be held at Ithaca, August, 1901.

The following papers were presented at the October meeting:

(1) PROFESSOR MAXIME BÔCHER: 'On linear dependence of functions of one variable.'

(2) PROFESSOR DAVID HILBERT: 'Ueber Flächen von constanter Gauss'scher Krümmung.'

(3) PROFESSOR E. O. LOVETT: 'Three notes on the geometry of contact transformations.'

(4) DR. G. A. MILLER: 'On a theorem in substitutions.'

(5) PROFESSOR S. L. PENFIELD: 'The solution of spherical triangles by graphical methods, and exhibition of scales and protractors for plotting.'

(6) MISS I. M. SCHOTTENFELS: 'On a set of definitional functional properties for the analytic function $f(z) = \frac{\tan \pi z}{\pi}$.'

(7) PROFESSOR P. F. SMITH: 'Geometry within a linear spherical complex.'

(8) DR. E. J. WILCZYNSKI: 'Invariants of systems of linear differential equations.'

(9) MR. H. W. KUHN: 'Several theorems on imprimitive groups'

After the meeting several members of the Mathematical and Physical Societies dined and passed the evening together.

The next meeting of the Society will be the Annual Meeting for the election of officers, Friday, December 28, 1900.

F. N. COLE,
Secretary.

DISCUSSION AND CORRESPONDENCE.

ON THE SUPERINTENDENCY AND ORGANIZATION OF THE COAST SURVEY.

IN view of the fact that the superintendency of the U. S. Coast and Geodetic Survey is about to pass from the present incumbent to some successor, the following statements may be of interest:

First, as regards the selection of a superintendent. Here there ought to be no serious difficulty; for, although persons suitable and available for the position are not numerous, the appointing power is free to select from all who may become known to him. He is not, like the voter, practically confined in his choice to two or three nominees. It seems proper that scientific bodies (notably the National Academy of Sciences), if not called upon as advisers, should take the initiative and bestir themselves, in order that a suitable man for this important position may be selected. Let them at least formulate the requirements for the place; then he who best measures up to such requirements should be the one to be selected. Or, perhaps better still, an advisory committee of mathematicians, physicists and astronomers might be appointed by the Chief Executive from this Academy and the faculties of our leading universities. What is wanted is a man of mature intellect and broad and thorough scholarship. If possible, he should already have made for himself a substantial reputation in the scientific world—this would, in fact, be a proof of his thoroughness and perseverance. But let no man be selected whose sole claim is a little technical skill or a familiarity with the organization. This remark is in no wise intended to decry the importance of experience, whether in field, laboratory or observatory.

It is perhaps not very generally understood that the organization of the Survey is radically wrong or at least not such as should underlie a scientific bureau in our day and generation. Its one fatal defect is its semi-military character. I say *semi*-military because it is open to that favoritism so much complained of in our late Spanish War, without having the wholesome restrictions thrown about a purely military organization. This places a fortunate few in virtual control of the many. In some instances this might be excused on the ground of the necessities of the case; in other words, in certain matters there must be some head. But if the fortunate few are assumed to have, by virtue of their positions, a monopoly of all brain tissue, and so are made to constitute the sole advisers of the superintendent in all matters relating to the work of the Survey, and even in the elevation and degradation of the personnel, it becomes evident to any disinterested observer that no universal good-fellowship can exist—and without this, good scientific work is impossible.

Suppose this oligarchy were to fortify itself behind certain rules designed for bureaus whose work is chiefly clerical; then an employee not specially empowered to look after others must needs be very guarded in his associations with his co-workers. Thus it might readily come to pass that persons working for years in the office at allied work scarcely have a speaking acquaintance with one another. Free discussion of work between non-commissioned employees would probably be frowned upon as seditious or as nursing conspiracies. The dangers of such a system to scientific work and thought are so obvious to anyone that its defense can hardly be seriously entertained. But there are other dangers as well as a great injustice in the system; for the management might fall into the hands of unscrupulous parties. In matters purely scientific, if there is to be any subordination, the smaller intellects should do homage to the greater; and in matters in general, unless there are most cogent reasons to the contrary, the older and more experienced should have the directing of the younger. This is a law of natural instinct and is in accordance with the laws of logic and of ethics; it is not to be lightly set aside. But enforced or artificial superiority and inferiority might put inferior minds over the superior, and make tyros chiefs of divisions and of field parties.

In this brief space no elaborate scheme of reorganization will be attempted. But it is safe

to say here that the following considerations are of fundamental importance:

1. Abolish all distinction between field and office force.

2. Leave all examinations or other tests of qualifications for appointment into the Survey wholly with the Civil Service Commission. If the Commission cannot propound suitable questions, let it consult the faculties of our leading universities. But let them never appeal to the bureau interested, save as to the general scope of the examination or other tests. If the bureau can dictate to the Commission, there is grave danger that it will override the latter and frame requirements suited to some person in whom it is interested. Again, ridiculously specific or technical questions do not well test a man's capacity nor his ability for doing work.

3. So far as possible, let the individuals do that kind of work for which they are best fitted because of their education, ability and natural liking.

4. Then base promotions in salary upon the quality and quantity of work done, unless it works obvious injustice to known abilities not well brought out by the assigned work.

5. The same rule should generally be applied in the selection of chiefs of divisions and of field parties. In doubtful cases favor the older candidates.

6. Let no set of employees have the ear of the superintendent while the other employees are seldom or never consulted.

7. Grant the greatest possible freedom in the pursuit of the work. Favor, and do not discourage, free consultation between all members of the Survey.

The preceding remarks show that much depends upon the selection of a superintendent. They show how important it is that he should be a scholarly man capable of properly judging the merits of the persons employed, also that he should encourage scientific activity as generally as possible throughout the bureau.

OBSERVER.

NOTES ON INORGANIC CHEMISTRY.

AN interesting paper by J. C. A. Simon Thomas, on the liquid carbon dioxid of commerce, has recently appeared in the *Zeitschrift für angewandte Chemie.* The author was incited to his investigation by the widely varying prices for the liquefied gas as supplied in steel cylinders for use in the ice machines on Dutch men-of-war. The gases examined were obtained from combustion of coke (Ozouf's method), from magnesite, from carbonaceous rock, 'prepared artificially' (no further data obtainable), and from the natural carbonic acid gas from certain volcanic regions. Gas from brewery fermentation was not obtained. The gases were all found to be of fairly good quality. No sulfurous acid gas nor hydrogen sulfid was found in any case. The natural gas contained considerable water, but this was probably introduced accidentally into the cylinder. The other gases left little, if any, residue. The natural gas was almost perfectly pure, containing only a trace (0.8 per cent.) of air. The Ozouf gas and that from carbonaceous rock contained respectively 2 per cent. and 5.7 per cent. of air. That from magnesite and that artificially prepared contained 4 per cent. and 3.4 per cent. of carbon monoxid. This was doubtless due to the presence of the reducing materials used in the decomposition. This impurity should not be present when the gas is used in ice machines in confined spaces, as on men-of-war, as the machines are liable to leak when first set to work. These quantities of impurities are found in the first portions of the gas drawn from the cylinders, and after half the gas has been drawn off, the amount of gas unabsorbed by caustic potash is inappreciable. The result of this investigation is to show that the quality of liquid carbon dioxid furnished by the European manufacturers leaves little to be desired.

SINCE the investigation of the metallic carbids by Moissan, the electric furnace has been applied to the preparation of many compounds of a similar nature, and some of these, like calcium carbid and carborundum, have already found important industrial applications. A paper was read before the Chemical Section at the Bradford meeting of the British Association by C. S. Bradley, on a series of silicids discovered by Charles B. Jacobs of New York, which may prove to be of commercial value. They are silicids of calcium, strontium and barium, with the formulæ $CaSi_2$, $SrSi_2$ and $BaSi_2$, thus

corresponding to the carbids. They are formed in the electric furnace from mixtures of the carbonates with sand, and sufficient carbon to effect a reduction, or silicates of the alkaline earths and carbon may be used. When treated with water, hydrogen is evolved; with dilute acids the calcium compound evolves silicon acetylene, Si_2H_2. They are powerful reducing agents, and may find use in the dye-stuff industries. They have also been found to be effective in removing phosphorus and sulfur from molten steel.

A RECENT issue of the *Chemical News* gives a description of the electrolytic refining plant of Boston and Montana Copper and Silver Mining Company of Great Falls, Montana, and of the Anaconda Copper Mining Company. It is an excellent instance of the revolution which is being worked in many industries by the use of electricity. In these plants the ore is ground and concentrated, and the rough metal is then cast in pigs two feet square and two inches thick. These are used as the anodes in the bath, the kathodes being thin sheets of copper. The refined copper is deposited upon these thin sheets, while the refuse from the pigs falls to the bottom of the bath. This refuse consists chiefly of lead, silver and gold, and is said to be worth about $2,600 a ton. This refuse is sufficient to pay for the whole electrolytic process. The process is carried on without intermission and the effective result is seen in the dividends of these companies.

J. L. H.

RECENT ZOO-PALEONTOLOGY.

A RHINOCEROS WITH A COMPLETE SET OF CUTTING TEETH.

THE chronometer of evolution never errs. It is well known that modern rhinoceroses are distinguished by the loss of most, if not all, of their cutting teeth. On evolution principles it has been predicted that they sprang from ancestors with four cutting teeth.

A few years ago the American Museum party found a maxilla containing the ancestral upper canines, and now F. A. Lucas (*Proc. U. S. Nat'l, Mus.*, No. 1207) has described a still older type, *Trigonias osborni*, with a full set of upper cutting teeth, that is, canines and three incisors, the most anterior of which is enlarged, Fig. 1. In the lower jaw there is some evidence that the enlarged teeth, which have been usually described as canines, are really incisors, because

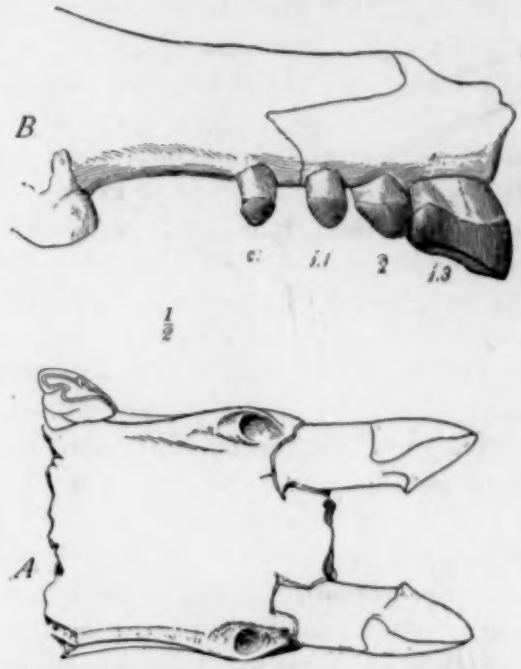

FIG. 1.—*Trigonias osborni*. *A*. Jaw showing alveoli of supposed canines. *B*. Anterior portion of cranium, showing three incisors and small canine. After Lucas.

vestiges of small teeth are present just behind them. This is a most interesting discovery from the Lower Oligocene beds of South Dakota and carries the line of the Rhinoceroses one step further back. The animal is almost as large as the classic *Aceratherium occidentale* of Leidy.

EXTINCT LEMURS FROM MADAGASCAR.

DR. C. J. FORSYTH MAJOR has described from time to time the remarkable lemurs of ancient Madagascar, a zoological region otherwise known as 'Lemuria'; they are of Pleistocene age and show a high degree of specialization or adaptive radiation. *Megaladapis* (see *Phil. Trans.*, Vol. 193, pp. 47–50, 1900) is by far the largest monkey hitherto described; as the name implies, it imitates on a large scale the well-known *Adapis* of the Oligocene of France. Another type, *Nesopithecus* (*Proc. Zool. Soc.*, Dec. 19, 1899), is remarkable in its adaptive resemblance to the Hypsiprimnid marsupials of Australia, proving that the lemurs are a group

which in past time imitated other groups more closely.

PAREIASAURIANS OR THERIODONTS IN NORTHERN RUSSIA.

A Russian naturalist, Amalitzky, has made extremely important discoveries in northeastern Russia of a Permian fauna which resembles in part that of Scotland and of this country, but still more closely that of the Permian or Perm-Trias fauna of South Africa. In a recent paper before the Society of Naturalists of St. Petersburg, Dec. 28, 1899, he reports the discovery of 39 groups of bones in concretions, 5 of which are composed of complete skeletons, with 5 others more or less complete, and 10 large groups of scattered bones. They include horned types similar to *Elginia* of Scotland and *Dicynodon* of South Africa. Although imbedded in a very difficult matrix, probably the animals are in a remarkable state of preservation and they will not only add greatly to our knowledge of this important fauna, which is ancestral to all the modern reptiles, amphibians and mammals, but they actually afford the most striking evidence of the cosmopolitan distribution of land vertebrates in Permian times.

FOSSIL MAMMALS FROM EGYPT.

Africa is the dark continent of Vertebrate Paleontology. With the exception of the Permian fauna of the South, and the Pleistocene fauna of the extreme North (which was virtually a part of Europe), Africa is a blank, although there is little doubt that a most important evolution of mammals was in process there from the beginning of the Tertiary period. It is therefore of great interest to record the discovery, 100 miles nearly due west from Cairo, of a species of Anthracothere to which the name *Brachyodus africanus* is given by Mr. Andrews.* The horizon is Lower Miocene and the beds are alternating fluviatile, marine and lacustrine deposits.

EXTINCT BIRDS OF PATAGONIA.

We are also indebted to Charles W. Andrews (*Trans. Zool. Soc.*, London, October, 1899) for a very careful review of the fossil ratite birds of Patagonia, remarkable for their great size and their incomplete parallelism with the ratites of other countries. These birds do not, like many other fossils which have recently been discovered in South America, add to the series of animals which connects this continent with Australia and New Zealand. On the other hand, they are, according to Mr. Andrews, entirely of independent origin. In fact, he concludes: "In the preceding pages only a few of the types with which the fossils have been compared are mentioned, they being the only types to which any resemblance pointing to possible affinities could be made out. And even among these there are some to which the similiarity is so slight that they also might perhaps have been omitted. For instance, in the case of *Diomedea*, it is only in the structure of the palate and one or two other points in the skull that any similarity with *Phororhacos* can be detected, the rest of the skeleton being strongly against any such relationship. In fact, it seems to the writer that the only groups that really come into question are the Falconiformes and aberrant Gruiformes, Carima, Chunga, and to a less degree Psophia." The general appearance of the skull is like that of the Falcons, while the general structure of the skeleton, particularly of the pelvis and hind limbs is strongly in favor of affinity with the storks and cranes. The especial type studied, *Phororhacos*, stands in somewhat the same relation to the Cariamidæ (Crested Screamer, Chunga) as such forms as Glyptodon stand to the modern Armadillos.

RELATION OF SOUTH AMERICAN AND AUSTRALIAN MARSUPIALS.

R. Lydekker (*Proc. Zool. Soc.*, 1899, pp. 927), while discussing the dental formula of marsupial and placental carnivores, states as his opinion, that the Prothylacinidæ, of Patagonia, equivalent to the Sparassodonta of Ameghino, are undoubtedly marsupials and that they are not very far removed from the Dasyures of Australia, of which they may represent the ancestral type. Lydekker also recedes from his former position that all the Mesozoic mammals should be classed as marsupials in the strict sense.

He has recently described *Ibid*, p. 919 f. from Chubut, Patagonia, a new Dolphin to which

* *Geol. Mag.*, Decade IV., Vol. VI., p. 481 f.

the name Prosqualodon is given because of the resemblance of its teeth to those of Squalodon. The same author has previously described Argyrodelphis, so that this is the second primitive cetacean from this region.

LARGE TURTLES FROM THE FORT PIERRE OF SOUTH DAKOTA.

G. R. WIELAND has recently given a full description (*Amer. Jour. Sci.*, April, 1900) of his genus *Archelon* which he proves to be related to, but distinct from, *Protostega*. It comes from the Fort Pierre of South Dakota, both the skull and part of the skeleton being remarkably preserved. This great sea tortoise belongs to the family Protostegidæ Cope, but its relations to the modern sea turtles or Chelonidæ cannot yet be positively ascertained. None the less this family (Protostegidæ) is much nearer the Chelonidæ than is the existing family, Dermochelyidæ, or modern leather-backed tortoises. In other words, Wieland differs from Baur, who placed the genus *Spahrgis* near the marine turtles, and inclines to the view of Cope and Boulenger that they belong in the separate division Atheca.

DINOTHERIUM GIGANTISSIMUM.

(Anuarulu Museului De Geologia si de Paleontologia * * * 1894, 1896.)

THIS memoir is accompanied by a very interesting and complete history of *Dinotherium* and of the remarkable theories which have been entertained at various times as to the relationships of this animal. Although the genus has been known for half a century, there being three species: *Dinotherium cuvieri*, characteristic of the Lower Miocene; *Dinotherium bavaricum*, characteristic of the Upper Miocene, and *Dinotherium giganteum*, characteristic of the Lower Pliocene of Europe, little has been known of these animals except the skull, so that their relations to the other Proboscidia have been very obscure. Professor Stefanescu, of Bucharest, has recently described a species from the Pliocene, which, as its name indicates, is much larger than *Dinotherium giganteum*. The type is remarkably preserved and shows that, wholly unlike the elephant, this animal has a functionally tridactyl pes, the first digit and probably the fifth being greatly reduced. The skeleton was exhumed in Roumania, near the village of Mansati, between 1890 and 1894.

FOSSIL CAMELS OF EUROPE.

THE same author has recently described a fossil camel from Roumania, the first which has been known in Europe; previous remains have been found in the Pliocene Siwalik beds of India, in the Pleistocene of Algeria and in the Pleistocene of Siberia, the latter teeth being preserved in the Museum of Darmstadt, and described by Bojanus in 1836 as *Merycotherium sibiricum;* the fossil nature of these teeth is somewhat in question. There can be no doubt however about the discovery in Roumania because the bones were associated with those of an Antelope and a Mammoth. After a most careful comparison and description, M. Stefanescu remarks that the animal probably emigrated from Asia but did not find its way into Europe until the Pleistocene; this species therefore adds a very important new type to the Pleistocene fauna of Europe.

THE DEVONIAN LAMPREY AND THE CLASSIFICATION OF THE FISHES.

Part 1 of Vol. II. of the *Memoirs* of the New York Academy of Sciences contains an important study of *Palæospondylus* by Bashford Dean. Since its discovery by Traquair in 1890 in the Devonian of Scotland, this minute fossil has attracted an amount of attention in inverse proportion to its size. Traquair placed it with the Cyclostomes; Huxley, with the larval Coccosteans; Gill, in a new sub-class, Cycliæ. Dean reviews the discussion and re-studies all the material with great care, coming to the conclusion that the specimens hitherto found are not adult: 'It is far more likely to prove, as Huxley believed, a larval Arthrodire.' The Arthrodira include the armored fishes *Dinichthys* and *Coccosteus*, and the most striking as well as the most permanent feature of Dean's paper is a separation of these types into a new distinct sub-class, ARTHROGNATHI, distinguished by the hinged condition of the jaws both at their junction with the skull and with each other. This is probably an important advance in the classification of the fishes and it has already been accepted by Woodward and Eastman.

HENRY F. OSBORN.

SECTION OF HORTICULTURE AND BOTANY OF THE ASSOCIATION OF AGRICULTURAL COLLEGES AND EXPERIMENT STATIONS.

THE meeting of the Section of Horticulture and Botany of the Association of Agricultural Colleges and Experiment Stations convened in New Haven, Connecticut, November 13th, with S. A. Beach, as Chairman, and Professor P. H. Rolfs, as Secretary. The program was as follows:

1. 'The Function of the Station Botanist,' Dr. George E. Stone, Amherst, Mass.; Discussion led by Professor P. H. Rolfs, Clemson College, S. C.

2. 'Plant Physiology in its Relation to Agriculture and Horticulture,' Albert F. Woods, Chief of Division of Vegetable Physiology and Pathology, Washington, D. C.

3. 'Grasses and Forage Plant Investigation in Experiment Stations and the Division of Agrostology,' Thomas A. Williams, Division of Agrostology, Washington, D. C.

4. Instructional Work. (*a*) 'Laboratory and Field Work for Students in Horticulture,' Professor E. S. Goff, Madison, Wis. (*b*) 'The Nature Study Movement,' Professor L. H. Bailey, Ithaca, N. Y. (*c*) 'The Educational Status of Horticulture,' Professor Fred. W. Card, Kingston, R. I.

5. Variety Testing and Plant Breeding. (*a*) 'Progress of Variety Testing in Experiment Station Work,' Professor F. William Rane, Durham, N. H. (*b*) 'What our Experiment Stations have done in Originating Varieties of Plants by Crossing and Selection,' Dr. B. D. Halsted, New Brunswick, N. J. (*c*) 'The Relation of the Section of Seed and Plant Introduction to Experiment Stations,' Jared G. Smith, Section of Seed and Plant Introduction, Washington, D. C. (*d*) Discussion led by Dr. Walter T. Swingle, Washington, D. C., and Professor Willet M. Hays, St. Anthony Park, Minn.

6. 'A Vegetable House arranged for Pot Experiments,' Mr. W. E. Britton, Horticulturist, New Haven, Conn.

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*THE ANNUAL CONGRESS OF THE GERMAN ANTHROPOLOGICAL SOCIETY.**

THE Thirty-first Congress of the German Anthropological Society was held in the University town of Halle from September 24–27. In addition to its rich University collections, a special interest is attached to Halle as being the seat of the oldest German society for encouraging the study of natural science, viz., the Leopoldina-Carolina Academy, which is thus comparable to the Royal Society in this country. To the students of prehistoric archeology, the Prussian province of Saxony is chiefly interesting from the fact of the existence of the copper-mines at Eisleben, some little distance from Halle. The meetings were held under the presidency of Professor Virchow, assisted by Professor Ranke. At the opening session on Monday, September 24th, the presidential address (dealing with the general progress of anthropological study and teaching) was followed by a series of addresses from representatives of the University and town of Halle, of which that of the local secretary, Dr. Förtsch, is particularly noteworthy as containing a sketch of local prehistoric archeology, a field of research in which Dr. Förtsch has been particularly active, and which he has popularized with evident success. Of the subsequent communications to the Congress, the majority which dealt with archeology, there appear to us most worthy of mention the discussion opened by Professor Virchow on the 'Earliest Appearance of the Slavs in Germany,' and the account (illustrated with excellent lantern slides) given by Dr. Birkner (Munich) of the investigation of the graves of the German emperors in Speyer. Professor v. Fritzsch (Halle) and Dr. Lehmann-Nitzsche (La Plata) rendered interesting accounts of discoveries of prehistoric man in Thüringia and in the Argentine respectively, the latter record being still the subject of investigation as regards the exact antiquity (Tertiary period) claimed for the find.

It is a matter of some surprise that the department of physical anthropology should not have been the subject of more papers than were actually presented at Halle, which University claims the two Meckels and Welcker among its former professors of anatomy. The chief contributions to this subject were those of Dr. Schmidt-Monnard (Halle) on the relation between the growth and the weight of children of both sexes; of Dr. Eisler (Halle) on the *Musculus sternalis;* and of Professor Klaatsch (Heidelberg) on the method of research adopted by anatomists, illustrated specifically by obser-

* From *Nature.*

vation on the 'short head' of the Biceps femoris muscle in the mammalian series.

The chief excursion of the Congress was made on Wednesday, September 26th, to Eisleben, where the copper mines already referred to were visited, and demonstrations of copper-smelting were given by representatives of the Mansfield Co. Subsequently the local collection of prehistoric pottery, etc., was inspected.

The concluding session was held on September 27th, when the presidency (for the ensuing year) was assumed by Professor Waldeyer (Berlin). It is a matter of interest to note that the Congress was made the occasion of circulating 'special inquiry' sheets regarding the structure and building of boats in all parts of Germany. General proposals regarding cartography and systematic records for provincial localities were brought forward by Dr. Voss (Berlin).

In addition to the anthropologists already mentioned in the foregoing notes, there were present Freiherr v. Andrian-Werburg (Vienna), Professor Hein (Vienna), Professor Montelius (Stockholm), Professor Koganei (Tokio), and others to the number of about 120.

SCIENTIFIC NOTES AND NEWS.

PROFESSOR SCHIAPARELLI retired on November 1st from the directorship of the Observatory at Milan, where he has been at work for the past forty years. His successor is Professor Celoria, heretofore assistant astronomer at the Observatory.

THE vacancy caused by the death of William Saunders, for the past 38 years superintendent of Experimental Gardens and Grounds, U. S. Department of Agriculture, has been filled by the appointment of B. T. Galloway, who in turn has been succeeded by Albert F. Woods as chief of the Division of Vegetable Physiology and Pathology.

DR. T. A. GEDDES, of the Bureau of Animal Industry, Department of Agriculture, has been detailed as a special inspector and ordered to Great Britain to inspect cattle intended for importation into the United States. Dr. Geddes sailed on November 7th.

PROFESSOR FREDERICK STARR, of the University of Chicago, has received a silver medal from Queen Wilhelmina, of Holland, as an acknowledgment for the anthropological collection sent by him to the National Museum of Holland.

DR. W. C. RÖNTGEN has written from Munich, under date of October 3d, a letter to the President of Columbia University, of which the following is a translation:

From the Secretary of our University I received yesterday the Barnard Medal awarded to me, together with your esteemed letter of June 13th.

Through the bestowal of this medal by a scientific institution, so illustrious as Columbia University, acting in conjunction with the National Academy of Sciences, my work upon the X-rays has received a recognition which, though in my own estimation greater than it deserved, has nevertheless pleased me very much and will be a spur to further effort.

Permit me, Mr. President, to request you to convey to Columbia University my warmest thanks.

MR. WILLIAM ANDERSON, professor of anatomy to the Royal Academy of Arts, London, died on October 27th at the age of fifty-eight years. He was the author of numerous contributions to anatomy and surgery, and the relation of these sciences to the fine arts. He was for some years director of the Naval Medical College at Tokyo, where he made valuable collections now in the British Museum.

DR. JOSEPH MIK, a distinguished dipterologist, died at Vienna on October 13th at the age of sixty-two years.

SURGEON MAJOR REED and a board of experts will continue the investigation into the propagation of yellow fever by mosquitoes, and an experimental station will be established outside Havana.

THE Secretary of Agriculture has published the following general order: "For the purpose of unifying the work of certain branches of the Department, it is hereby ordered that the Chief of the Division of Vegetable Physiology and Pathology, the Chief of the Division of Agrostology and the Chief of the Division of Pomology confer upon all matters of general policy and plan with the Superintendent of Experimental Gardens and Grounds, who is hereby designated as Director of Plant Industry. In carrying out this order the several branches of the Department named will maintain their pres-

ent integrity and organization." A laboratory for the physical and chemical study of road materials has been established in the Division of Chemistry. "The object of the establishment of this laboratory is to secure the widest possible knowledge of the nature of road materials, their resistance to stress, their hardness, their power of absorbing water, their deportment in freezing temperatures, their cementing properties when reduced to powder, either alone or when mixed with other substances, their chemical composition and their geological origin and distribution."

It is reported that M. Daniel Osiris, a Greek millionaire, residing in Paris, has instituted a prize on the lines laid down by Mr. Nobel, though his offer is for Frenchmen only, except in a Paris Exposition year, when it becomes universal. He has set aside a sum to be awarded every three years in perpetuity to the discoverer, inventor or producer of the most noteworthy idea or object for the benefit of humanity. The prize is to be never less than 100,000 francs, and may be double that sum.

Edgar J. Townsend, professor of mathematics, and Cyril G. Hopkins, professor of agronomy, have returned to the University of Illinois after a leave of absence. Both have been studying during their absence abroad at the University of Göttingen, from which institution each has received the degree of Ph.D. Professor Townsend studied pure mathematics under Professors Hilbert and Klein and the mathematics of physics under Professor Voigt. Professor Hopkins has been studying under Professor Tollans.

Professor B. B. Ross, of the Alabama Agricultural and Mechanical College and Experiment Station, has been granted a year's leave of absence, which he is spending in chemical investigation in Germany.

Professor F. W. Woll, chemist of the Wisconsin Experiment Station, is spending a year in special study abroad.

President Henry S. Pritchett, of the Massachusetts Institute of Technology, made an address on November 8th before the Boston Society of Arts on 'America's Contribution to the Knowledge of the Size and Figure of the Earth.'

Mr. L. B. Stillwell, formerly electrical director of the Niagara Falls Power Company, and now in charge of the electrical installation work of the Manhattan Railway Company, has been appointed electrical director of the New York Rapid Transit Subway Construction Company.

In memory of the late Dr. R. T. Manson, F.G.S., the naturalist and geologist, a large granite boulder, has, as we learn from *Nature*, been taken from the bed of the River Tees and placed on a pedestal in the Public Park, Darlington. The stone weighs about twelve tons, and it is admitted to have come originally from Shap, in Westmoreland, in the Great Ice Age.

The well known collection of mammals of E. A. and O. Bangs, comprising more than ten thousand specimens (in most cases skins accompanied by skulls) and over one hundred type specimens, has been presented to the Museum of Comparative Zoology of Harvard University through friends of the Museum.

There has been recently received at the National Zoological Park, Washington, D. C., a specimen of Steller's sea-lion (*Eumetopias stelleri*), from the Pribilof Islands.

It is stated that the German Government has purchased Count Zeppelin's airship and that it will be taken to Berlin.

The Indian Government will give an annual subsidy of £650 for three years to the Pasteur Institute at Kasouli, of which Major Semple is director.

The daily papers report that Dr. Leopold Kann has arrived at Dundee on the Whaler *Eclipse*, bringing news, not only of Dr. Robert Stein and Mr. Samuel Warmbath, but also of Lieutenant Peary and Captain Sverdrup. Lieutenant Peary is said to be now wintering at Fort Conger and has apparently put off his attempt to reach the far north until next year. Captain Sverdrup, on the *Fram*, is said to be wintering in Jones Sound.

St. Petersburg scholars are planning a scientific expedition to examine the manuscripts at

Moukden, discovered by Russian troops, among them being ancient Greek and Roman documents, supposedly taken by the Mongolians on their retreat from the Occident. They are believed to be of great historical value.

THE Peabody Museum is sending this week an expedition to continue the work of exploration in the ruined and prehistoric city of Copan, in Central America.

THE United States Civil Service Commission invites attention to the fact that in view of the statement of the Department of Agriculture that no appointment is expected to be made at present to the position of assistant biologist, the examination scheduled for November 20, 1900, for the position of assistant biologist in the Department of Agriculture, will not be held at that time and not until further notice.

FROM a private letter the following paragraph of interest to astronomers is taken: "The latest news concerns the building of a fine new meridian circle by Repsold for the observatory at Kiel. It is to be of eight inches aperture with all possible modern improvements; a full equipment of collimators, wires, etc. Of the latter two are to be at 60 meters distance and a third at 4,000 meters. There is to be a floating mirror suspended over the instrument for observations to supplement the usual nadir observations. The building is to be semi-cylindrical with double walls about 12 meters square, and if I understand the matter correctly, the entire building is to be in two parts, so that the slit for observations is formed by separating the parts in the east and west direction. Professor Harzer is responsible for the design, I believe. The purpose for which the instrument is designed is the observation of faint, close circumpolar stars for latitude variation according to the method which has been used at the Paris Observatory, and the Prussian government is to furnish the money."

THE *London Daily Mail* states that the postal departmental commission will shortly report, after some months of deliberation, in favor of the earliest possible adoption of Marconi's system of wireless telegraphy by the postal authorities. The commission is also arranging terms for the acquisition of the Marconi patents, and negotiating with France and Germany regarding their attitude toward Marconi's inventions.

A FURTHER item of interest in regard to the Marconi system is the statement that when the Ostend-Dover mail packet *Princess Clementine* was nearing Dover, on November 9th, a message was received on board from La Panne. It was retransmitted to the Marconi station at Dover Court, in Essex, more than eighty miles distant.

THE Pennsylvania Experiment Station has for some time been engaged in the construction of a respiration calorimeter on the general plan of the Atwater-Rosa respiration calorimeter, but adapted in size and mechanical arrangement to use in investigations with the larger domestic animals. In the experiments with man many of the operations are performed by the subject himself, but the problem in experiments with animals is much more complicated. Accordingly the adaptation of the apparatus to animals has called for the exercise of much ingenuity in providing devices which will make the apparatus more largely automatic, or allowing all the operations connected with an experiment to be managed from without the respiration chamber. The apparatus is approaching completion. After being thoroughly tested it will be used for studying the fundamental problems connected with the nutrition of live stock. Comparatively little work of this character has as yet been done by the American experiment stations, and it is hoped that with the aid of this new apparatus the Pennsylvania Station will be able to achieve important results in a field where there is every year more pressing demand for exact information.

THE Association of Agricultural Colleges and Experiment Stations is this week meeting at New Haven under the presidency of Dr. Joseph E. Stubbs, president of the Nevada State University.

AT a recent meeting of the Röntgen Society in London, Dr. J. B. Mackintyre stated that medical men were disappointed at the limited value of the X-rays in medical work. In the army hospitals in South Africa, however, the X-rays were found most useful. Seventeen

sets of apparatus had been sent to the field. They were now being adopted and supplied to all the larger military hospitals.

At the tenth annual meeting of the British Astronomical Association, held on October 31st, Mr. W. H. Maw referred to the observations made on the solar eclipse and spoke at length of the automatic appliances for obtaining photographs which Professor David P. Todd of Amhers tCollege has devised and which he used with success this year. Professor Todd hopes to employ his apparatus on a more extended scale in observations of next year's eclipse in Sumatra.

At the last meeting of the Congress of American Physicians and Surgeons a committee was appointed to urge upon Congress the repeal of those provisions of the War Revenue Act of 1898 which lay a tax on legacies to educational, charitable and religious organizations. The committee, which consists of Professors Frederrick C. Shattuck, Abraham Jacobi and William H. Welch, has written to the members of the Congress asking them to take an active interest in the subject by addressing members of the Senate and House of Representatives. Others interested in education and science should unite in the efforts for the repeal of this legislation.

The government of Argentine has published a decree declaring that Villa Concepcion is infected with the plague, and that other Paraguayan ports are suspicious.

In the French Senate M. Piot has introduced a bill aiming to arrest the depopulation of France. It provides for a tax on celibates of both sexes after they reach the age of 30, and upon childless couples who have been married for five years, the tax to be maintained until a child is born to them.

A communication on the influence of the temperature of liquid hydrogen on bacteria was recently presented to the Royal Society by Dr. Allan Macfadyen and Mr. Sydney Rowland. In a previous communication these gentlemen had shown that the temperature of liquid air has no appreciable effect upon the vitality of micro-organisms, even when they are exposed to this temperature for one week (about — 190° C.) They now report, we quote from the *British Medical Journal*, that they have been able to execute preliminary experiments as to the effect of a temperature as low as that of liquid hydrogen on bacterial life. As the approximate temperature of the air may be taken as 300° absolute, and liquid air as 80° absolute, hydrogen as 21° absolute, the ratio of these temperatures roughly is respectively as 15 : 4 : 1. In other words the temperature of liquid hydrogen is about one-quarter that of liquid air, just as that of liquid air is about one-quarter of that of the average mean temperature. In subjecting bacteria, therefore, to the temperature of liquid hydrogen, the experimenters place them under conditions which, in severity of temperature, are as far removed from those of liquid air as are those of liquid air from that of the average summer temperature. By the kindness of Professor Dewar the specimens of bacteria were cooled in liquid hydrogen at the Royal Institution, the following organisms being employed : B. acid lactici, B. typhosus, B. diphtheriæ, proteus vulgaris, B. anthracis, B. coli communis, staphylococcus pyogenes aureus, spirillum choleræ, B. phosphorescens, B. pyocyaneus, a sarcina and a yeast. These organisms in broth culture were sealed in thin glass tubes and introduced directly into liquid hydrogen contained in a vacuum jacketed vessel immersed in liquid air. Under these conditions they were exposed to a temperature of about — 250 ° C. (21° absolute) for ten hours. At the end of the experiment the tubes were opened, and the contents examined microscopically and by culture. The results were entirely negative as regards any alteration in appearance or in vigor of growth of the micro-organisms. It would appear, therefore, that an exposure for ten hours to a temperature of about — 250° C. has no appreciable effect on the vitality of micro-organisms. Dr. Macfadyen and Mr. Rowland hope in a future communication to extend their observation upon the influence of the temperature of liquid hydrogen on vital phenomena, and to discuss their bearing upon problems of vitality.

The new session of the Royal Geographical Society, London, as we learn from the London *Times*, began on November 12th, when it was expected that the president, Sir Clements Mark-

ham, would give a brief introductory address, to be followed by a paper by Dr. A. Donaldson Smith on his recent remarkable journey through Somaliland to Lake Rudolf, and across from Lake Rudolf to the Nile and home by Khartoum and Cairo. The second paper, on November 26th, will be by Mr. J. E. S. Moore, on his recent expedition for the scientific exploration of Lake Tanganyika and the interesting region to the north. At the meeting of December 10th Major Gibbons will give an account of his exploration of the Barotse country and his journey thence through Africa to the Mediterranean. After Christmas among the papers expected are one by Colonel G. E. Church, on the geography of South America, with special reference to its commercial development, and another on 'Further Studies in Wave Form,' by Mr. Vaughan Cornish. It is hoped that the Duke of the Abruzzi may be able to arrange to go to England some time next year before the end of the session and give the Society an account of his recent remarkable expedition towards the North Pole.

AT the opening of the new scientific laboratories at King's College, London, which took place on October 30th, Lord Lister made an address in which, according to the London *Times*, he said that it might seem strange that so large a gathering of distinguished men should come to witness the opening of certain laboratories. Yet the occasion was not unworthy of celebration, for it was an event of significance in regard to the provisions for higher education in the metropolis. It was recognized that mere lectures were not sufficient, that practical instruction was imperatively necessary. In some branches King's College was long ago well equipped to this end; the Wheatstone Museum contained a fine collection of physical apparatus, and in chemistry nothing could be better than the arrangements for practical teaching. The same might be said of other departments, but not of all. The dissecting room was by no means adequate, and the accommodation for the practical teaching of physiology was simply miserable, while there were defects in less degrees in other departments. Of these the Council had long been conscious, and, having determined to remedy them, had provided the new laboratories, which, as visitors would admit, were highly satisfactory. The laboratory for practical physiology in all its branches was now second to none in the country. It had really been in use for some time, and had attracted many students, not only from King's College, but from elsewhere. Its removal to the second floor gave room for the expansion of the anatomical department, and at the same time there had been provided a fine anatomical museum, which, however, was not yet equipped. The bacteriological laboratory had received an important addition. This laboratory, which owed its inception to Professor Crookshank, though it attracted advanced students not only from this country but from the world, had hitherto consisted of a single apartment which was not suitable for research work. For this latter purpose a new room had now been added, and a fine class-room had also been constructed, common to the professors of bacteriology and physiology. No doubt his audience had watched with interest, and rejoiced at the success of the endeavors made to check the outbreak of plague in Glasgow, and they must also have felt a sense of relief when the suspected case in the metropolis was found not to be plague; in both cases the means employed were entirely due to researches of the kind carried on in bacteriological laboratories. But it was not only the medical faculty of King's College that had benefited by the alterations. Geology now had accommodation proportionate to the importance of the subject, and in the architectural department there was abundant room for men engaged in drawing and designing. In short, King's College was abreast of the age as regards opportunities for practical teaching in all departments. It was a happy coincidence that this great addition to its resources had been made at the time when it was entering on a new career as one of the colleges of the new University of London. He himself would have liked to see the old examining university retained and a separate teaching university established. But other views prevailed, and a compromise had been effected under which examining and teaching existed side by side in the same institution. He wished the compromise all the success it was capable of, and ven-

tured to express the hope that, now the matter was decided, all would work together for the common good.

UNIVERSITY AND EDUCATIONAL NEWS.

In addition to her recent gifts of $100,000 and $10,000 which we have recently announced, Mrs. Jane K. Sather, of Oakland, has presented to the University of California real estate worth $150,000.

Mr. William Waldorf Astor has contributed $50,000 to the benefaction fund of Cambridge University, England.

Columbia University has received a further anonymous gift of $10,000 for the purchase of books.

At the annual meeting of the Council of New York University it was reported that the gifts to the institution during the year had amounted to $348,000.

At a recent meeting of the Board of Trustees of Columbia University the committee on buildings and grounds was authorized to select a site and prepare plans for a college hall.

The main building of the Cornell University Veterinary College was partly burned on Tuesday. The apparatus destroyed was worth $10,000; the total loss is $30,000.

The Yale Forestry School has opened with an enrollment of seven regular students and seventeen from other departments of the University. The residence of the late Professor O. C. Marsh is used as a school building. In addition to lecture rooms, a library, laboratory and a herbarium room have been furnished with such equipment as is necessary for the present requirements of the school. A considerable amount of museum material has already been acquired by the school and is being classified and arranged as rapidly as possible. The grounds about the building, 10 acres, are already covered with a great variety of trees and shrubs, both native and foreign, and it is the intention to plant a considerable number of varieties which are not represented. A forest nursery will be established on the grounds, but the regular forest planting will be done on waste land on the outskirts of New Haven. The New Haven Water Company has offered to the school the use of several hundred acres of woodland for the practical field work of the students, and several other owners have expressed their desire to devote their wood-lots to this purpose. The degree of master of forestry will be given to such graduates of the school as have previously received the bachelor's degree from collegiate institutions of high standing.

A botanical school is being erected at a cost of $20,000 in Shealey Park, Pittsburg. It is intended especially for children in the schools, as it is believed that they can carry on the study of botany to greater advantage in a special laboratory than in the school-room.

Trinity College for the higher education of women, near the Catholic University at Washington, will be dedicated towards the end of the present month. Its educational work has already begun.

Mr. T. Nelson Dale, geologist of the U. S. Geological Survey, has resigned his instructorship in geology and botany at Williams College and his curatorship of the College Museum.

The following appointments have been made at Columbia University: W. W. Comstock, assistant in physics; Hardy Chambiss and W. E. Dryfus, assistants in chemistry; Charles E. Banker, assistant in normal histology, and Carlton P. Flint, assistant in demonstrative anatomy.

Mr. I. H. Derby, B.A. (Harvard, 1899), and F. C. Koch, M.A. (Illinois, 1900), have been appointed instructors in chemistry at the University of Illinois. At the same university, Mr. E. W. Ponzer, B.A. (Illinois, 1900), has been appointed instructor in mathematics.

Dr. Alfred L. T. Schaper, formerly assistant professor of histology at the Harvard Medical School, has been appointed professor extraordinary of anatomy, and director of the division for embryology and bio-mechanics at the University of Breslau.

Professor Georg Meissner, director of the Physiological Institute at Göttingen, will retire at the end of the present college term on account of ill health.